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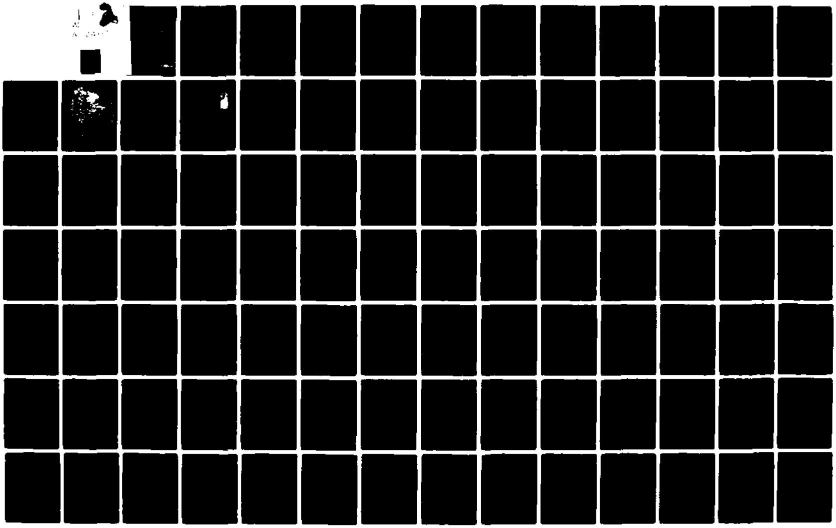

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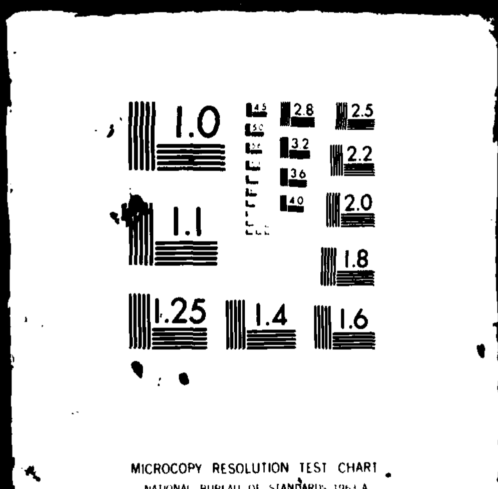

MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION

AD A112407

AGGREGATE RESOURCES STUDY
PINE VALLEY
WAH WAH VALLEY
UTAH

PREPARED FOR
BALLISTIC MISSILE OFFICE (BMO)
NORTON AIR FORCE BASE, CALIFORNIA

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1. REPORT NUMBER FN-TR-37-9	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (*and Subtitle*) Aggregate Resources Study, Pine Valley, Wah-Wah Valley, Utah		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER FN-TR-37-9
7. AUTHOR(s) Fugro National, Inc.		8. CONTRACT OR GRANT NUMBER(s) F04704-80-C-0006
9. PERFORMING ORGANIZATION NAME AND ADDRESS Ertec Western Inc. (formerly Fugro National) P.O. Box 7765 Long Beach Ca 90807		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 64312 F
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Department of the Air Force Space and Missile Systems Organization Norton AFB Ca 92409 (SAMSO)		12. REPORT DATE 27 Feb 81
		13. NUMBER OF PAGES 46
14. MONITORING AGENCY NAME & ADDRESS (*if different from Controlling Office*)		15. SECURITY CLASS. (*of this report*)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)

Distribution Unlimited

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

Distribution Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

Geology, ~~Setting~~, ~~Potential~~ aggregate, ~~sources~~ petrography, grain size, trench logs, caliche

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

This report contains the Valley-Specific Aggregate Resources Study evaluation fo Pine and Wah Wah valleys and surrounding areas in Utah. It is the seventh in a series of reports that contain valley-specific aggregate information on the locat and suitability of basin-fill and rock sources for concrete and road-base constru materials. The findings presented are based on field reconnaissance and limited laboratory testing, existing data from the Utah State Department of Highways, previous regional aggregate investigations, and ongoing Verification studies.

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AGGREGATE RESOURCES STUDY

PINE - WAH WAH

UTAH

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

Prepared by:

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27 February 1981

FOREWORD

This report was prepared for the Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract No. F04704-80-C-0006, CDRL Item No. 004A6. It presents the results of Valley-Specific Aggregate Resources investigation within and adjacent to selected lands in Utah and Nevada that are under consideration for siting the MX system.

This volume contains the results of the Aggregate Resources study in Pine and Wah Wah valleys. It is the seventh of several Valley Specific Aggregate Resources investigations which will be prepared as separate volumes. Results of this report are presented as text, appendices, and two drawings.

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EXECUTIVE SUMMARY

This report contains the Valley-Specific Aggregate Resources Study (VSARS) evaluation for Pine and Wah Wah valleys and surrounding areas in Utah. It is the seventh in a series of reports that contain valley-specific aggregate information on the location and suitability of basin-fill and rock sources for concrete and road-base construction materials. The findings presented are based on field reconnaissance and limited laboratory testing, existing data from the Utah State Department of Highways, previous regional aggregate investigations, and ongoing Verification studies.

A classification system based on aggregate type and potential use was developed to rank the suitability of all basin-fill and rock aggregate sources. Four aggregate types have been designated; coarse, fine, and coarse and fine (multiple) aggregates derived from basin-fill sources, and crushed rock aggregates derived from rock sources. Each aggregate type was then classified using the following definitions:

Class I Potentially suitable concrete aggregate or road-base material source;

Class II Possibly unsuitable concrete aggregate/potentially suitable road-base material source; and

Class III Unsuitable concrete aggregate or road-base material source.

Decisions on assigning a particular aggregate source to one of the three classes were determined from existing test data and

Fugro National laboratory aggregate tests performed as part of this study (abrasion resistance, soundness, and alkali reactivity) and, to a lesser degree, field visual observations.

Emphasis in this study was placed on the identification of Class I basin-fill coarse aggregate. These deposits are considered to be the primary sources of concrete and road-base construction materials. Results of the study are presented on a 1:125,000 scale aggregate resources map (Drawing 2) and are summarized as follows:

1. Coarse Aggregate - Major Class I coarse aggregate deposits are located in the Pine and Wah Wah valley study area in:

   a. Alluvial fan deposits (Aafc, Aafs) adjacent to the Wah Wah Mountains in eastern Pine Valley;

   b. Older lacustrine deposits (Ao1g) in east-central Wah Wah Valley; and

   c. Alluvial fan (Aafs) and older lacustrine (Ao1s, Ao1g) deposits along the western side of Wah Wah Valley.

   Potentially suitable Class II coarse aggregate sources are widespread in the study area. They are typically located within alluvial fan (Aafs, Aafg) and older lacustrine (Ao1g, Ao1s) deposits flanking Class I and/or Class II rock sources.

2. Fine Aggregate - Class I fine aggregate (multiple-type) sources were delineated in:

   a. Alluvial fan deposits (Aafs) in east-central Pine Valley; and

b. Older lacustrine deposits (Aolg) in east-central Wah Wah Valley.

Potential Class II fine aggregate sources typically occurring basinward of most Class I and Class II rock exposures are extensively distributed throughout the study area.

Many coarse aggregate basin-fill sources are also potential multiple sources (coarse and fine) that will supply varying quantities of fine aggregate either from the natural deposit or during processing.

3. Crushed Rock - Abundant Class I crushed rock sources are present throughout the study area in:

   a. Precambrian quartzite and Prospect Mountain Quartzite (QTz) in San Francisco and central Wah Wah mountains;

   b. Notch Peak and Guilmette formations (Cau) in Wah Wah Mountains and Needle Range;

   c. Marjum Formation (Ls) in the Wah Wah Mountains and in northwestern Wah Wah Valley;

   d. Fish Haven, Laketown, Sevy, and Simonson dolomites (Do) in Tunnel Spring and Wah Wah mountains, and Needle Range;

   e. Diorite intrusive (Gr) in San Francisco Mountains; and

   f. Basalt (Vb) in northern Wah Wah Valley and extreme southwestern part of study area.

The usability of any of these rock units as sources of crushed rock aggregate depends on their accessibility and minability within the study area.

Additional aggregate testing and field investigations will be required to further refine the lateral and vertical extents of

classification boundaries and define exact physical and chemical characteristics of a particular deposit or rock source within the study area.

1.0 INTRODUCTION

1.1 STUDY AREA

This report presents the results of the Valley-Specific Aggregate Resources Study (VSARS) completed for Pine and Wah Wah valleys (Figure 1). The study area is located in portions of western Iron, Beaver, and Millard counties, Utah. Pine and Wah Wah valleys are north-south trending alluvial basins separated by mountain ranges of sedimentary, igneous, and metamorphic rocks (Tunnel Springs, Wah Wah, San Francisco mountains; Needle and Star ranges.). Bordering the area are Snake Valley, Tule Valley, and Sevier Desert on the north and the Escalante Desert on the east and south. Utah State Highway 21 provides paved road access across the central portion of the area. A network of unpaved roads and four-wheel drive trails provide access throughout the study area.

The study area is mainly comprised of desert rangeland managed by the Bureau of Land Management (BLM). The Desert Range Experimental Station, located in northwestern Pine Valley is managed by the State of Utah. The town of Milford, Utah is located east of the study area.

1.2 BACKGROUND

The MX aggregate program began in 1977 with the investigation of Department of Defense (DoD) and BLM lands in California, Nevada, Arizona, New Mexico, and Texas (FN-TR-20D). Refinement of the MX siting area added portions of Utah and Nevada that were not

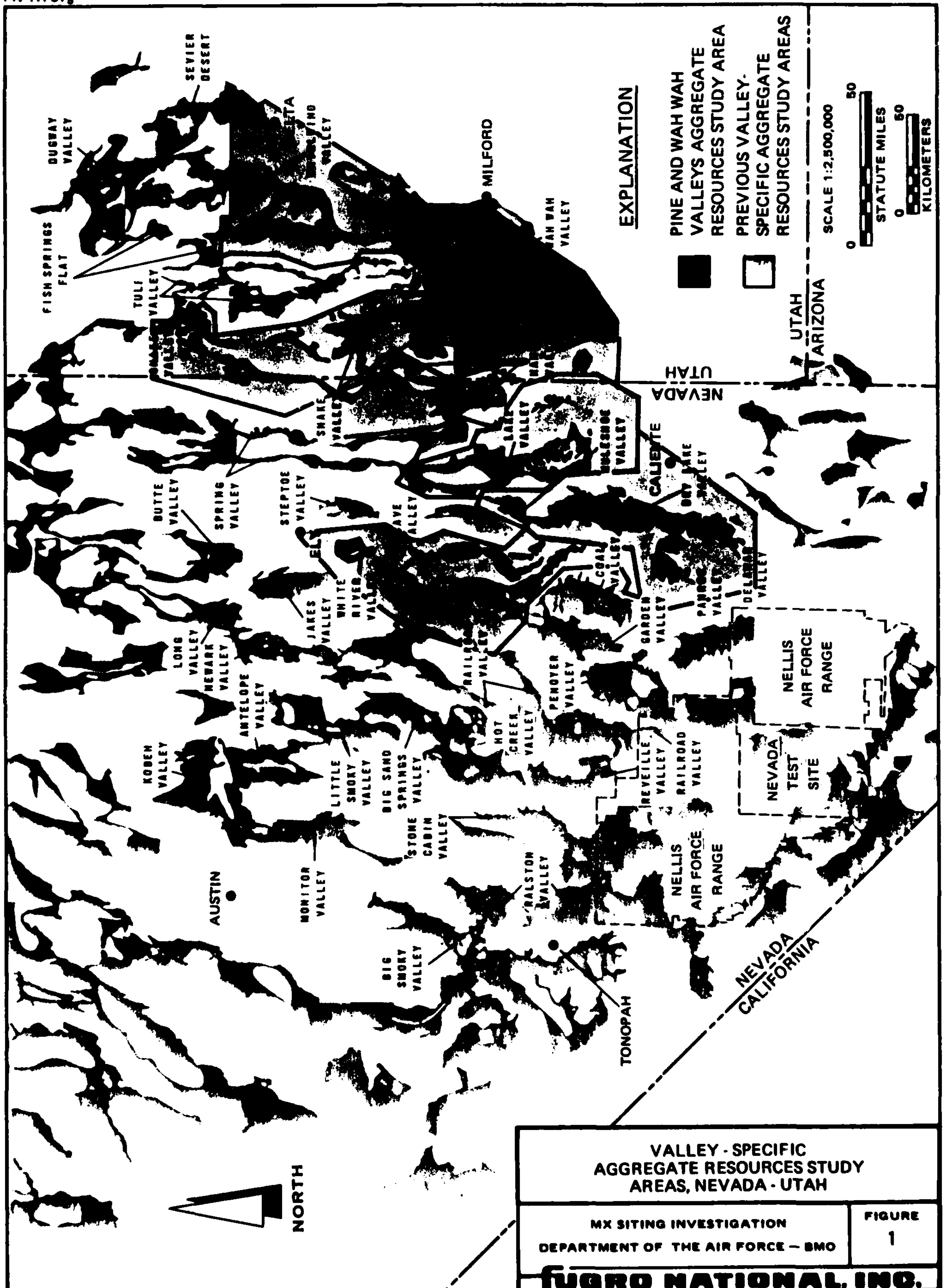
EXPLANATION
PINE AND WAH WAH VALLEYS AGGREGATE RESOURCES STUDY AREA
PREVIOUS VALLEY-SPECIFIC AGGREGATE RESOURCES STUDY AREAS
SCALE 1:2,500,000
0 50 STATUTE MILES
0 50 KILOMETERS
NORTH
SEVIER DESERT
DUGWAY VALLEY
FISH SPRINGS FLAT
TULE VALLEY
MILFORD
WAH WAH VALLEY
SNAKE VALLEY
UTAH
NEVADA
ARIZONA
LAKE VALLEY
PATTERSON VALLEY
DRY LAKE VALLEY
CALIENTE
BUTTE VALLEY
SPRING VALLEY
STEPTOE VALLEY
ELY
CAVE VALLEY
JAKES VALLEY
WHITE RIVER VALLEY
COAL VALLEY
GARDEN VALLEY
PAHROC VALLEY
DELAMAR VALLEY
LONG VALLEY
NEWARK VALLEY
ANTELOPE VALLEY
RAILROAD VALLEY
PENOYER VALLEY
HOT CREEK VALLEY
NELLIS AIR FORCE RANGE
KOBEH VALLEY
LITTLE SMOKY VALLEY
BIG SAND SPRINGS VALLEY
REVEILLE VALLEY
RAILROAD VALLEY
NEVADA TEST SITE
STONE CABIN VALLEY
AUSTIN
MONITOR VALLEY
RALSTON VALLEY
NELLIS AIR FORCE RANGE
BIG SMOKY VALLEY
TONOPAH
NEVADA
CALIFORNIA
VALLEY - SPECIFIC AGGREGATE RESOURCES STUDY AREAS, NEVADA - UTAH
MX SITING INVESTIGATION
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FIGURE 1
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studied in the initial Aggregate Resources Evaluation Investigation (AREI). This additional area (Figure 2), defined as the Utah Aggregate Resources Study Area (UARSA), was evaluated in the fall 1979, and a second general aggregate resources report (FN-TR-34) was submitted on 3 March 1980. Both general aggregate investigations were designed to provide regional information on the location, quality, and quantity of aggregates that could be used in the construction of the MX system.

Subsequent to the general studies, VSARS were developed in FY 79 to provide more-detailed information on potential aggregate sources in specified valley areas.

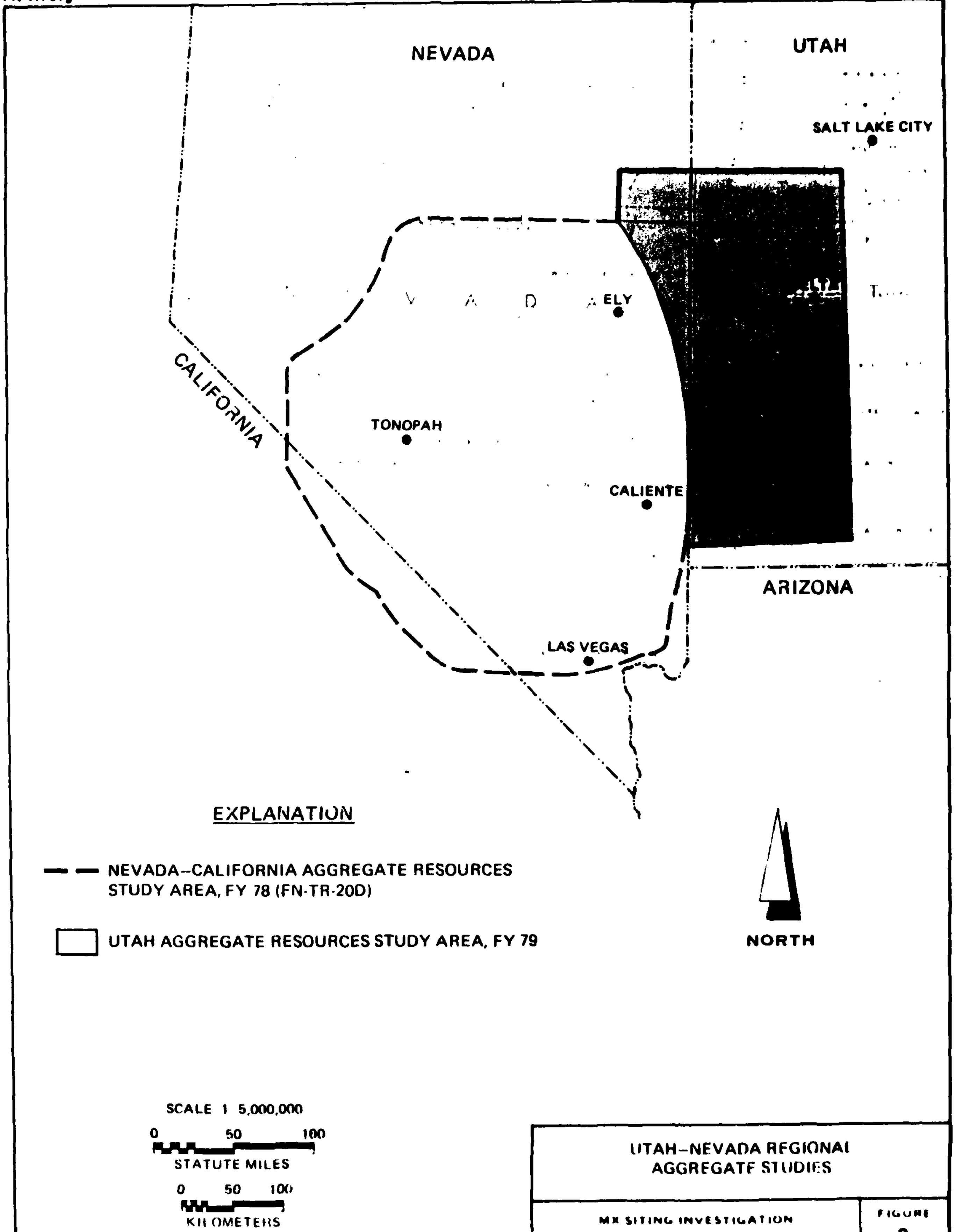
1.3 OBJECTIVES

The primary objective of the VSARS program is to classify, on a valley basis, basin-fill deposits and rock units for suitability as concrete and road-base construction materials. The Valley-Specific Aggregate Resources Study format is designed to select and present the locations of the most acceptable aggregate sources for preliminary construction planning and follow-on detailed aggregate investigations.

1.4 SCOPE

The scope of this investigation required office and field studies and included the following:

1. Collection and analyses of available existing data on the quality and quantity of potential concrete aggregate and road-base material sources. American Society of Testing and Materials (ASTM) standards and Standard Specifications for Public Works Construction (SSPWC) were used to evaluate quality;



UTAH–NEVADA REGIONAL AGGREGATE STUDIES

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE BMO

FIGURE 2

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2. Aerial and ground reconnaissance of all identified potential aggregate sources in the valley area, with more-detailed investigation and sample collection of likely basin-fill (coarse and fine aggregates) and rock (crushed rock aggregates) construction material sources;

3. Laboratory testing to supplement available existing data and to provide detailed information to assist in determining the suitability of specific basin-fill or rock as construction material sources within the study area; and

4. Development and application of an aggregate classification system (Section 2.5) that emphasizes aggregate type (coarse, fine, or crushed rock) and potential construction use (concrete and/or road base).

2.0 STUDY APPROACH

2.1 EXISTING DATA

Collection of existing test data from available sources was an important factor in the VSARS program. The principal source of existing data pertaining to aggregate construction materials was the Utah State Department of Highways (Appendix A). The majority of this information is related to the use of aggregate material for asphaltic concrete, base coarse in road construction, or ballast material; however, many of the suitability tests for these types of construction materials are similar to those for concrete and are applicable to this investigation (Appendix A).

2.2 SUPPLEMENTAL FUGRO NATIONAL DATA

Supplemental Fugro National data were obtained from: 1) field data and supplementary test data collected during the general aggregate resources studies (FN-TR-34), 2) Pine and Wah Wah Valley Verification studys (FN-TR-27), and 3) the current (Appendix A) and previous (FN-TR-37) Valley Specific Aggregate Resources Studies in surrounding areas.

The primary objective of the initial general aggregate study was a regional evaluation and ranking of all potential aggregate sources. Thirty-eight data points from the general aggregate studies were located within the VSARS area (Drawing 1). These data supplied specific aggregate information which included one 150-pound sample collected for limited laboratory testing (Appendix A).

Verification geologic maps are an initial source of information on the type and extent of basin-fill units within specific valley areas. While the Verification studies are not specifically designed to generate aggregate information, some of the data collected are applicable to the aggregate evaluation. Data from 18 Verification trenches were used in the evaluation of grain-size gradations in the study area (Appendix A). Depths of the selected trenches ranged from 5 to 13 feet (1.5 to 4.0 m).

The VSARS program required aerial and ground reconnaissance of the study area to collect additional information to verify conditions determined during the data review. Included in the 72 field station data stops was the collection of 50 samples for additional laboratory testing. Potential coarse- and fine-aggregate basin-fill samples were collected by sampling stream cuts or man-made exposures. Potential crushed rock aggregate samples were obtained from exposures of fresh or slightly weathered material whenever possible. The weight of the samples collected ranged between 100 and 150 pounds. Hand samples, which generally did not exceed 5 pounds in weight, were collected from rock units for office analyses.

Identification of basin-fill materials in all field studies followed ASTM D 2488-69 Description of Soils (Visual-Manual Procedure), and the Unified Soil Classification System (Appendix C). Rock identifications followed procedures described in the Quarterly of the Colorado School of Mines (1955) and Standard Investigative Nomenclature of Constituents of Natural Mineral Aggregates (ASTM C 294-69).

2.3 DATA ANALYSIS

Geologic and engineering criteria were used in the evaluation of potential aggregate sources within the study area. This was supplemented by laboratory analysis of selected samples during the valley-specific aggregate testing program (Table 1). Coarse aggregate is defined as plus 0.185 inch (4.75 mm) fine gravel to boulder basin-fill material. Fine aggregate is defined as less than 0.375 inch (9.5 mm) and predominantly less than 0.185 inch (4.75 mm), but greater than 0.0029 inch (0.074 mm), coarse to fine sand basin-fill material. While all laboratory tests supplied definitive information, the soundness, abrasion, and alkali reactivity results were considered the most critical in determining the use and acceptablity of a potential aggregate source.

2.4 PRESENTATION OF RESULTS

Results of the study are presented in text, tables, appendices, and two 1:125,000 scale maps. Drawing 1 presents the location of the 150 Fugro and existing data sites within the study area. Drawing 2 presents the location of all VSARS laboratory sample sites and all potential basin-fill and rock aggregate sources within the study area. In addition, these potential aggregate sources are classified according to proposed aggregate use and type (Section 2.5).

Geologic unit symbols utilized in Drawing 2 relate to standard geological nomenclature whenever possible. Undifferentiated basin-fill deposits and rock units were established primarily to

ASTM TEST	SAMPLE TYPE AND NUMBER OF TESTS		
	COARSE	FINE	ROCK
ASTM C–88; SOUNDNESS BY USE OF MAGNESIUM SULFATE	31	32	16
ASTM C–131; RESISTANCE TO ABRASION BY USE OF THE LOS ANGELES MACHINE	30	NA	17
ASTM C–136; SIEVE ANALYSIS	33	33	NA
ASTM C–289; POTENTIAL REACTIVITY OF AGGREGATE (CHEMICAL METHOD)	16	9	9
ASTM C–127 AND C–128; SPECIFIC GRAVITY AND ABSORPTION	13	7	5

AGGREGATE RESOURCES STUDY
AGGREGATE TESTS
PINE AND WAH WAH VALLEYS

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TABLE 1

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accommodate accuracy of data and map scale and may contain deposits which could supply significant quantities of high quality materials. A conversion table to relate these geologic symbols to the geologic unit nomenclature used in Fugro National Verification studies is contained in Appendix E.

All contacts which represent distinct boundaries between geologic units are shown as solid lines in Drawing 2. The contacts are dashed where the data were extrapolated beyond the limits of the source data or where accuracy of the data may be questionable. Local small deposits of one geologic unit may be found in close association with a larger deposit of a different geologic unit. Due to the reconnaissance level of the field investigation or map scale limitations, these smaller deposits could not be depicted on the aggregate resources map and have been combined with the more prevalent material. Similarly, potential aggregate source classifications are preliminary and may contain lesser amounts of material of another use or type. Therefore, all classification lines are dashed and delimit the best aggregate evaluations possible at this level of investigation. In cases of highly variable rock or basin-fill units and limited aggregate tests, boundaries could not be drawn and information is presented as point data on Drawing 2.

Appendices contain tables summarizing the basic data collected during Fugro National's supplemental field investigations, the results of Fugro National's supplemental testing programs, and

existing test data gathered from various outside sources (Appendix A). Also included in appendices are an explanation of caliche development (Appendix B), the Unified Soil Classification System (Appendix C), photographs of typical aggregate sources within the Pine and Wah Wah valleys study area (Appendix D), and a geologic unit cross-reference table (Appendix E).

2.5 PRELIMINARY CLASSIFICATION OF POTENTIAL AGGREGATE SOURCES

A system was developed to preliminarily classify all potential aggregate sources in the study area. This classification is designed to present the best potential sources of coarse, fine, coarse and fine (multiple source), and crushed rock aggregate types within a valley-specific area (Drawing 2) based on potential aggregate use (Table 2). Concrete aggregate parameters are the principal consideration in this report as materials suitable for use as concrete aggregate and generally acceptable for use as road-base material. Therefore, the three classifications described below are based primarily on results of the abrasion, soundness, and alkali reactivity tests.

Class I — Potentially suitable concrete aggregate or road-base material sources. Coarse and crushed rock aggregates which either passed abrasion, soundness, and alkali reactivity tests or passed abrasion and soundness tests and were not tested for alkali reactivity; fine aggregates which either passed soundness and alkali reactivity tests or passed soundness tests and were not tested for alkali reactivity.

Class II — Possibly unsuitable concrete aggregate/potentially suitable road-base material source. Coarse, fine, and crushed rock aggregates which either failed the soundness and/or alkali reactivity tests or were classified only by field visual observations or other test data.

AGGREGATE CHARACTERISTIC[1]			AGGREGATE USE CLASSIFICATION		
			CLASS I	CLASS II	CLASS III
ABRASION RESISTANCE, PERCENT WEAR[2]			< 50	< 50	> 50
SOUNDNESS, PERCENT LOSS[3]	COARSE AGGREGATE	Na SO_4	< 12	> 12	> 12
		Mg SO_4	< 18	> 18	> 18
	FINE AGGREGATE	Na SO_4	< 10	> 10	> 10
		Mg SO_4	< 15	> 15	> 15
POTENTIAL ALKALI REACTIVITY[4]			INNOCUOUS TO POTENTIALLY DELETERIOUS	DELETERIOUS	DELETERIOUS

1. AGGREGATE CHARACTERISTIC BASED ON STANDARD TEST RESULTS
2. ASTM C131 (500 REVOLUTIONS)
3. ASTM C88 (5 CYCLES)
4. ASTM C289

PRELIMINARY AGGREGATE CLASSIFICATION SYSTEM, VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY

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TABLE 2

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Class III <u>Unsuitable concrete aggregate or road-base material</u>. Coarse and crushed rock aggregates which failed abrasion test and were excluded from further testing. Fine and occasionally coarse aggregates composed of significant amounts of clay- and silt-sized particles.

Sources not specifically identified as Class I, II, or III from the three critical test results or clay- and silt-sized particle content are designated as Class II sources. All classifications are preliminary with additional field reconnaissances, testing, and case history studies needed to confirm adequacy, delimit areal boundaries, and define exact physical and chemical characteristics.

The following publications/sources were used in defining the three use classifications:

1. ASTM C33-74A Standard Specifications for Concrete Aggregate;
2. SSPWC Part II Construction Sections 200-1.1, 1.4, 1.5, and 1.7;
3. Literature applicable to concrete aggregates;
4. Industrial producers of concrete aggregates; and
5. Consultants in the field of concrete aggregates.

3.0 GEOLOGIC SETTING

3.1 PHYSIOGRAPHY

The study area lies entirely within the Basin and Range physiographic province (Fenneman, 1946). Primary physiographic features are controlled by block faulting which has produced the uplifted north-south trending mountains and intervening downdropped alluvial-filled basins.

The study area consists predominantly of two basins, Pine Valley and Wah Wah Valley, with bordering mountain ranges (Drawings 1 and 2). Pine Valley is bounded on the west by the Needle Range and Tunnel Spring Mountains and on the east by the Wah Wah Mountains. Wah Wah Valley is bounded on the west by the Wah Wah Mountains and on the east by the San Francisco Mountains and isolated peaks (Squaw Peak, Antelope Peak, and White Mountain). The Beaver Lake Mountains and the Rocky and Star ranges are located west and northwest of Milford, Utah, on the east side of the study area. The Escalante Desert forms the eastern and southeastern site boundaries. Elevations range from approximately 6800 to 5100 feet (2073 to 1554 m) in Pine Valley and from 6000 to 4600 feet (1829 to 1402 m) in Wah Wah Valley.

Drainage in Pine Valley is closed to the Pine Valley Hardpan except for the extreme southern part which drains to the Escalante Desert. Wah Wah Valley drainage is closed to the Wah Wah Valley Hardpan and Sevier Lake to the north. Drainage is to the north and east near Milford and to the east and southeast in the remainder of the Escalante Desert area.

3.2 LOCATION AND DESCRIPTION OF GEOLOGIC UNITS

Rocks of Precambrian, Paleozoic, Mesozoic, and Cenozoic age are exposed within the study area. Various igneous, metamorphic, and sedimentary lithologies are represented. Unconsolidated Quaternary alluvial deposits unconformably overlie the older rock units.

Precambrian rocks are exposed only in the San Francisco Mountains. This unit is predominantly medium- to thick-bedded metaquartzite with interbedded phyllite and argillite.

Paleozoic rocks are present throughout the study area. They consist predominantly of limestone and dolomite with appreciable thicknesses of orthoquartzite and minor thicknesses of interbedded sandstone, siltstone, and shale. Major exposures are located in the northern and central Needle Range, in the Tunnel Spring, Wah Wah, Beaver Lake, and San Francisco mountains, and in the Star Range. Metamorphosed Paleozoic carbonate rocks are exposed in the Beaver Lake Mountains.

Rocks of Mesozoic age are of limited areal extent within the study area. They consist of thin- to thick-bedded sandstone with interbedded conglomerate, siltstone, and shale. These rocks crop out in the southern Wah Wah Mountains and the Star and Rocky ranges.

Cenozoic rocks are exposed throughout the area. They consist predominantly of Tertiary igneous extrusive and intrusive rocks

with some isolated sedimentary units. Extrusive rocks are the most abundant and consist of ash-flow and air-fall tuffs and lava flows ranging in composition from basaltic to rhyolitic. These rocks are exposed throughout the southern part of the study area with isolated outcrops in the central and northern portions. Intrusive rocks, ranging in composition from diorite to granite, are exposed in the central Wah Wah Mountains, southern San Francisco Mountains, Star and Rocky ranges, and Beaver Lake Mountains. Tertiary sedimentary rocks that consist principally of moderately indurated, silica-cemented conglomerate are exposed locally in the southern Wah Wah Mountains and the northeastern San Francisco Mountains.

Quaternary alluvial deposits unconformably overlie older units and consist primarily of alluvial-fan, older-lacustrine, stream-channel-and-terrace, and eolian deposits (Drawing 2). Alluvial fans are the most extensive and widespread Quaternary deposit within the study area. Major older lacustrine deposits are concentrated in northern Pine Valley and are common throughout Wah Wah Valley.

These geologic units have been grouped into nine rock units and four basin-fill units for use in discussing potential aggregate sources. Grouping of these units is based on similarities in physical and chemical properties and map-scale limitations. The resulting units allow for simplicity of discussion and presentation without altering the conclusions of this study.

3.2.1 Rock Units

Geologic rock units were grouped into the following nine categories (Drawing 2): quartzite (Qtz), limestone (Ls), dolomite (Do), carbonate rocks undifferentiated (Cau), sedimentary rocks undifferentiated (Su), granitic rocks (Gr), basalt (Vb), volcanic rocks undifferentiated (Vu), and metamorphic rocks undifferentiated (Mu).

3.2.1.1 Quartzite - Qtz

Three quartzite units are present in the study area. They are an unnamed Precambrian quartzite, the Cambrian Prospect Mountain Quartzite, and the Ordovician Eureka Quartzite.

The unnamed Precambrian quartzite is exposed in the San Francisco Mountains. This unit consists of medium- to thick-bedded, fine- to medium-grained, purple to red-brown metaquartzite with interbedded argillite and phyllite.

The Cambrian Prospect Mountain Quartzite overlies the unnamed Precambrian quartzite and is exposed in the northern San Francisco and Beaver Lake mountains and along the western front of the central Wah Wah Mountains, south of Highway 21. The unit is over 4000 feet (1219 m) thick in the Wah Wah Mountains and consists of thin- to thick-bedded, fine- to medium-grained, pinkish-gray to reddish-brown orthoquartzite with interbedded sandstone, micaceous shale, and conglomerate.

The Ordovician Eureka Quartzite is exposed primarily in the central Needle Range and in the southern Tunnel Spring Mountains.

This unit is more than 400 feet (122 m) thick and consists of thin- to thick-bedded, fine- to medium-grained, light-brown to white orthoquartzite with interbedded sandstone and shale near the base and top of the unit.

3.2.1.2 Limestone - Ls

Limestone is a carbonate rock that comprises the majority of the Paleozoic section. Units mapped as limestone consist of the Marjum, Weeks, and Orr formations, Pogonip Group, Joanna Limestone, and minor-, middle-, and upper-Paleozoic limestones within the study area. These units are typically thin- to thick-bedded, fine- to coarse-grained, light- to dark-gray limestone with interbedded chert, sandstone, siltstone, and shale. Locally these units may be fossiliferous. Limestone units are mapped in the northern Needle Range, Wah Wah and San Francisco mountains, and locally in the eastern and southeastern part of the study area.

3.2.1.3 Dolomite - Do

Dolomite, a high magnesium content carbonate rock, is the second most abundant lithologic unit in the Paleozoic section. Formations mapped as dolomite are the Fish Haven, Laketown, Sevy, and Simonson. These units are exposed in the northern Needle Range, the Tunnel Spring Mountains, and the southern Wah Wah Mountains and are typically medium- to thick-bedded, fine- to coarse-grained, medium- to dark-gray dolomite with interbedded chert, sandstone, and siltstone.

3.2.1.4 Carbonate Rocks Undifferentiated - Cau

Undifferentiated carbonate rock units were mapped where complex, interbedded sequences of limestone and dolomite were present or where map scale prevented delineation of individual units. Principal mapped formations include undivided Cambrian rocks, the Notch Peak and Guilmette formations, and localized exposures of upper Paleozoic carbonate rocks. The lithology of these units varies considerably (especially the undivided Cambrian rocks) but are typically medium- to thick-bedded, fine- to medium-grained, medium- to dark-gray dolomite and limestone with interbedded chert and sandstone. Undifferentiated carbonate rocks crop out throughout the mapped area.

3.2.1.5 Sedimentary Rocks Undifferentiated - Su

Undifferentiated sedimentary rocks were mapped where interbedded sandstone, siltstone, shale, limestone, and/or dolomite are exposed. The highly interbedded nature of these units prevents separation into individual rock types. Principal units consist of numerous lower- to upper-Cambrian formations, the Chainman Shale, numerous Mesozoic units, and the Tertiary conglomerates. Interbedded clastic and carbonate rocks typify the Cambrian formations and the Chainman Shale while interbedded clastic rocks typify the Mesozoic and Tertiary rocks. Undifferentiated sedimentary rocks are exposed in the northern Needle Range; the Wah Wah, San Francisco, and Beaver Lake mountains; and the Rocky and Star ranges.

3.2.1.6 Granitic Rocks - Gr

Granitic rocks of Tertiary age are exposed in the central Wah Wah, southern San Francisco, and Beaver Lake mountains and the Rocky and Star ranges. These units are typically medium-grained, moderately well-jointed, gray to brownish-gray granitic rocks. Composition ranges from dioritic to granitic with varying amounts of quartz, feldspar, and mafic minerals.

3.2.1.7 Basalt -Vb

Basaltic flows of Tertiary age are mapped in northern Wah Wah Valley, in the southwestern portion of the study area, and in other isolated locations throughout the site. The basalt is typically medium- to thick-bedded, very dense, brown to black, vesicular, and moderately to poorly jointed.

3.2.1.8 Volcanic Rocks Undifferentiated - Vu

Tertiary undifferentiated volcanic rocks comprise an extensive unit throughout the study area. This unit consists of a variety of interlayered volcanic ash-flow and air-fall tuffs and lava flows. Composition ranges from basaltic to rhyolitic but is generally dacitic to rhyolitic. Volcanic units are extensively exposed in the Needle Range; the Tunnel Spring, Wah Wah, San Francisco, and Beaver Lake mountains; the Rocky and Star ranges; and the area around Squaw Peak, Antelope Peak, and White Mountain.

3.2.1.9 Metamorphic Rocks Undifferentiated - Mu

Undifferentiated metamorphic rocks are mapped only in the Beaver Lake Mountains. They are predominantly light-gray, coarse-grained Paleozoic carbonate rocks that have undergone varying

degrees of metamorphism due to intrusion of the adjacent granitic rock.

3.2.2 Basin-fill Units

Four basin-fill units are mapped within the study area (Drawing 2). They consist of older lacustrine deposits (Aol), alluvial fan deposits (Aaf), stream channel and terrace deposits (Aal), and undifferentiated deposits (Au). Cobble (c), gravel (g), and sand (s) grain-size designations (e.g., Aafg) have been assigned to basin-fill units in the Verification mapped areas. Basin-fill units which have high silt and/or clay content are considered unsuitable aggregate sources (Class III) and will not be discussed. These units are active playas, alluvial fans, or older lacustrine deposits located generally near the valley center.

3.2.2.1 Older Lacustrine Deposits - Aol

Older lacustrine deposits are present in both Pine and Wah Wah valleys. Deposits were formed in Pine Valley during a period of higher rainfall in the Pleistocene when a small closed lake occupied the center of the valley to an elevation of approximately 5200 to 5300 feet (1585 to 1615 m). These deposits are typically poorly graded, moderately stratified gravelly sand.

Older lacustrine deposits in Wah Wah Valley were formed by Pleistocene Lake Bonneville. The highest strand elevation was approximately 5200 feet (1585 m). These deposits are more extensive than the deposits in Pine Valley because of the greater

size of Lake Bonneville. Older lacustrine deposits are typically poorly graded and moderately to well stratified. Deposits on the east side of Wah Wah Valley consist predominantly of boulders, cobbles, gravel, and sand derived from quartzitic source rocks. Deposits along the western side are generally gravel and sand with some cobbles, silt, and clay from carbonate and volcanic sources.

3.2.2.2 Alluvial Fan Deposits - Aaf

Alluvial fans form the most extensive basin-fill deposits in the study area. They are generally moderately well- to poorly graded, poorly stratified sandy gravel and gravelly sand. Alluvial fans are generally coarse grained near the mountain front and fine grained near the basin center. Fans derived from quartzite and carbonate rocks show a greater range of gradation (boulders to clay) and are coarser-grained near the mountain front, whereas, fans formed from volcanic and granitic areas are predominantly sand. Caliche development (Appendix B) ranges from none to Stage III, depending on fan age, composition, and gradation.

3.2.2.3 Stream Channel and Terrace Deposits - Aal

Stream channel and terrace deposits are widespread throughout the study area although most are too small to depict at the 1:125,000 map scale. Deposits that were mapped represent significantly large drainages and are typically poorly graded, moderately well-stratified sand with some gravel, cobbles, and boulders. Locally these units may be predominantly gravel.

3.2.2.4 Alluvial Deposits Undifferentiated - Au

Undifferentiated alluvial deposits consist of combinations of basin-fill units that were not delineated and mapped during the Verification program. In northern Pine Valley, this unit is composed of intermixed alluvial fan and eolian deposits. Undifferentiated alluvial deposits in the Escalante Desert area contain alluvial fan, older lacustrine, and stream channel and terrace deposits. These units are unstratified to stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay derived from a variety of rock sources.

4.0 POTENTIAL AGGREGATE SOURCES

Based on the results of field visual observations and aggregate testing, potential basin-fill and rock sources were divided into three basic material types (i.e., coarse, fine, and crushed rock) and classified into one of the three use categories (Section 2.5). Basin-fill deposits tested in the study area may also be placed within a multiple-type category (coarse and fine aggregate source). Coarse aggregate (gravel to boulders) included material predominantly retained on the No. 4 sieve (0.185 inch [4.75 mm]). Fine aggregate (predominantly sand) includes material entirely passing the 3/8 inch sieve (0.375 inch [9.5 mm]), almost entirely passing the No. 4 sieve (0.187 inch [4.75 mm]), and retained on the No. 200 sieve (0.0029 inch [0.074 mm]).

Classification boundaries (Drawing 2) of basin-fill aggregate sources were generalized and will require additional studies to accurately define their location. Boundaries of identified crushed rock sources are based on the areal extent of the geologic formations tested (i.e., Prospect Mountain Quartzite, Fish Haven Dolomite) and not on the aggregate geologic unit (i.e., Qtz, Do) described in Section 3.2.1.

In the following discussion, the best potential coarse, fine, or crushed rock source within each Class I and Class II category is presented first, followed by sources with successively lower potential. This ranking of deposits is preliminary and based upon an analysis of Fugro National and existing data.

4.1 BASIN-FILL SOURCES

4.1.1 Coarse Aggregate

4.1.1.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

In Pine Valley, Class I coarse aggregate sources are located in alluvial fan deposits (Aafc, Aafs) along the western side of the Wah Wah Mountains (Drawing 2). These fan units are predominantly moderately to poorly graded, poorly stratified, medium-dense sandy gravel composed of subangular to subrounded quartzite, limestone, and dolomite clasts. Laboratory tests showed acceptable abrasion, soundness, and alkali reactivity (where tested) results. Overburden, ranging from 1 to 3 feet (0.3 to 0.9 m), consists of soil horizons with Stage I to III caliche development. Good access to these deposits is provided by numerous unpaved roads which transect the area. Minability is considered good to excellent. Class I boundaries are tentative where shown, and additional field investigations will be necessary to accurately define all Class I coarse aggregate alluvial fan sources west of the Wah Wah Mountains.

Class I coarse aggregate sources are located in older lacustrine deposits (Aolg) along the east side of Wah Wah Valley (Drawing 2). These sources are located in shoreline features of Pleistocene Lake Bonneville and consist of poorly graded, moderately well stratified, moderately well-rounded sandy gravel with cobbles and boulders. Clasts are approximately 90 percent quartzite with minor amounts of carbonate and clastic rock fragments.

Laboratory tests show acceptable Class I results for abrasion, soundness, and alkali reactivity. Overburden ranges from 0 to 3 feet (0 to 0.9 m) and consists of a poorly developed soil with no to Stage I caliche development. Access is provided by a limited number of unpaved roads, and minability is good to excellent.

Additional Class I coarse aggregate sources are located along the west side of Wah Wah Valley (Drawing 2) in alluvial fan (Aafs) and older lacustrine deposits (Ao1s, Ao1g). Alluvial fan units are typically moderately to poorly graded, poorly stratified, medium-dense sandy gravel and gravelly sand. The older lacustrine deposits are poorly graded, moderately to well stratified, loose to medium-dense sandy gravel and gravelly sand. Clasts from both sources are derived predominantly from carbonate, and to a lesser degree, volcanic rocks. Overburden ranges from 0 to 3 feet (0 to 0.9 m) of soil with Stage I to III caliche development. Testing of all sources indicate acceptable results for abrasion, soundness, and alkali reactivity (where tested). Graded roads and four-wheel drive trails provide access to the area.

Other Class I sources are identified in alluvial fan deposits (Aafs, Aaf) in Pine Valley and in undifferentiated alluvial deposits (Au) in the Escalante Desert (Drawing 2). These units typically consist of moderately to poorly graded, poorly stratified, medium-dense, sandy gravel and gravelly sand. Although

boundaries for these units could not be drawn from the field reconnaissance and limited laboratory testing, most alluvial fan and undifferentiated alluvial deposits bordering Class I rock sources may qualify as Class I basin-fill sources.

4.1.1.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

Class II coarse aggregate sources are located in alluvial fan deposits (Aafs) in Pine and southern Wah Wah valleys and older lacustrine deposits in northern Wah Wah Valley (Drawing 2). These sources are typically moderately to poorly graded sandy gravel to gravelly sand. Samples failed to meet Class I standards for soundness or alkali reactivity (where tested). High soundness losses occurred in samples composed predominantly of volcanic rock clasts. Samples that were found to be deleterious were composed predominantly of quartzite clasts (Prospect Mountain and/or Precambrian quartzite). Minability and accessability are generally good to very good.

Additional sources of Class II coarse aggregate may be located within alluvial fans (Aaf, Aafs, Aafg) near Class I and Class II carbonate or quartzitic rocks and in unmapped older lacustrine units.

4.1.1.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

No unsuitable coarse aggregate sources were identified in the study area during the valley-specific investigation.

4.1.2 Fine Aggregate

4.1.2.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

A Class I fine aggregate source was delineated in alluvial fan deposits (Aafs) flanking the Wah Wah Mountains south of State Highway 21 in eastern Pine Valley (Drawing 2). Because of the presence of Class I coarse aggregates, this area is mapped as a multiple source (Section 4.1.1.1). It is typically moderately to poorly graded, poorly stratified, medium-dense sandy gravel with clasts composed predominantly of limestone, dolomite, and minor quartzite rock fragments. Soundness and alkali reactivity tests were within acceptable limits for Class I fine aggregate. Overburden is generally less than 3 feet (0.9 m) and consists of a soil horizon with Stage I to Stage II caliche development. Numerous unpaved roads transect the area and minability and accessibility are considered very good.

Class I fine aggregate sources are located in older lacustrine deposits (Ao1g) in east-central Wah Wah Valley. These are also mapped as multiple sources because of the high Class I coarse aggregates content (Section 4.1.1.1). Deposits are typically poorly graded, moderately stratified, loose to medium-dense sandy gravel and gravelly sand composed predominantly of quartzite clasts.

Laboratory testing indicates acceptable soundness and alkali reactivity results. Overburden consists of 0 to 3 feet (0 to 0.9 m) of poorly developed soil with no to Stage I caliche

development. Accessibility and minability are considered good to excellent.

Additional Class I fine aggregate sources are located in alluvial fan deposits (Aaf, Aafs) in Pine Valley and in older lacustrine deposits (Aolg, Aols) in Wah Wah Valley. These units are typically moderately to poorly graded sandy gravel to gravelly sand. Gravel comprises as much as 76 percent of these deposits (multiple-type sources) with clasts composed predominantly of carbonate and quartzite rock fragments. Laboratory tests meet acceptable standards for soundness and alkali reactivity (where tested). The accessability and minability of these sources are generally very good.

Based on field observations, additional Class I fine aggregate sources may exist in alluvial fans (Aaf, Aafs,Aafg) located adjacent to Class I and/or Class II crushed rock sources and in unmapped older lacustrine units.

4.1.2.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material Sources - Class II

Widespread Class II fine aggregate sources were identified from test results in all types of basin-fill deposits (Aaf, Aol, Au, Aal) within the study area. Tested samples failed to meet acceptable Class I standards for soundness and/or alkali reactivity. The physical properties, composition, and source of these samples varies widely. Field observations and laboratory test data for the sources are presented in Appendix A. Class II fine aggregate sources are typically located basinward of Class I

and Class II rock sources and should be available from most Class I and Class II basin-fill areas depicted on Drawing 2.

4.1.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

Class III fine aggregate sources are located in the central valley basins and are comprised predominantly of older lacustrine and recent playa deposits (Drawing 2). These sediments are typically interbedded, medium-dense fine sand and soft to stiff silt and clay.

4.2 CRUSHED ROCK SOURCES

4.2.1 Potentially Suitable Concrete Aggregate or Road-Base Material Sources - Class I

Class I crushed rock aggregate sources are distributed throughout the study area. The most extensive sources occur in the Tunnel Spring, Wah Wah, and San Francisco mountains and the Needle Range. Mapped units consist of: quartzite (Qtz) from the unnamed Precambrian and the Prospect Mountain formations; undifferentiated carbonate rocks (Cau) of the Notch Peak and Guilmette formations; limestone (Ls) from the Marjum Formation; dolomite (Do) from the Fish Haven, Laketown, Sevy, and Simonson formations; and igneous intrusive diorite (Gr) and basalt (Vb).

The unnamed Precambrian quartzite (QTz) crops out in the San Francisco Mountains, and the Prospect Mountain is exposed in the San Francisco, Beaver Lake, and central Wah Wah Mountains. These units have similar aggregate properties. They are typically very hard, thin- to thick-bedded, brown to purple quartzite with interbedded argillite, phylite, and conglomerate.

Laboratory tests show these units meet minimum requirements for abrasion, soundness, and alkali reactivity (where tested). Jointing characteristics are generally favorable for crushing, and minability and accessability are good to very good.

The Cambrian Notch Peak Formation (Cau) is exposed predominantly in the Wah Wah Mountains. It is typically hard, thin- to thick-bedded, medium- to dark-gray interbedded limestone and dolomite. Locally, some interbedded shale is exposed. Laboratory data for the Notch Peak Formation indicate acceptable results for abrasion, soundness, and alkali reactivity. Test data from Tule Valley (in progress) indicate similar results. Accessibility and minability are good in most areas near the alluvial fan and rock contact.

The Devonian Guilmette Formation (Cau) was not tested within the study area but is considered a Class I source from test results in nearby Snake Valley (FN-TR-37-b) and Hamlin Valley (FN-TR-37-e). This unit is exposed in the northern Needle Range and near White Mountain on the eastern border of the site. It consists of hard, thick-bedded, light- to dark-gray interbedded limestone and dolomite which may be locally sandy and/or silty. Accessibility and minability range from poor to good depending on location within the study area.

The Cambrian Marjum Formation (Ls) is exposed in the Wah Wah Mountains and in northwestern Wah Wah Valley. The Marjum is hard, thin- to very thick-bedded, dark-gray limestone with

interbedded light-gray shaley dolomite in the upper part. Laboratory tested samples meet acceptable Class I standards for abrasion and soundness but were untested for alkali reactivity. Splitting characteristics, minability, and accessibility are good to very good, especially in the Wah Wah Mountains in northeastern Pine Valley and outcrops in northwestern Wah Wah Valley.

The Ordovician Fish Haven Dolomite (Do) is exposed in the Tunnel Spring Mountains, the central Needle Range, and in northern Pine Valley. This unit is hard, thin-bedded, medium- to dark-brown-gray dolomite with acceptable splitting characteristics. Test results indicate this unit meets Class I requirements for abrasion, soundness, and alkali reactivity. Accessability and minability are good to very good.

The Silurian Laketown Dolomite (Do) and the Devonian Sevy and Simonson dolomites (Do) were not tested within the study area but are considered Class I sources because of favorable test results in other VSARS areas (Snake Valley, FN-TR-37-b; Hamlin Valley, FN-TR-37-e; Tule Valley, in progress). They are typically hard, thin- to thick-bedded, medium- to dark-gray dolomites with favorable splitting characteristics. These units crop out predominantly within the northern Needle Range and Tunnel Spring and southern Wah Wah mountains and are considered to have very poor to good accessibility and minability.

The Tertiary diorite intrusive (Gr) exposed in the southern San Francisco Mountains is considered a Class I crushed rock aggregate source. It is characteristically a light-gray hard,

medium-grained, moderately well-jointed exposures with acceptable splitting characteristics. Mineral composition is approximately 50 percent feldspar, 20 percent quartz, and 30 percent mafic minerals. Test results indicate this unit meets Class I requirements for abrasion, soundness, and alkali reactivity. Accessibility and minability are very good. Compositional variation prevents mapping of other granitic units (Gr) in the study area as Class I rock sources.

Basalts exposed in northern Wah Wah Valley and the southwestern part of the study area are considered Class I sources. The basalt in northern Wah Wah Valley was tested and found to meet Class I requirements for abrasion, soundness, and alkali reactivity. This unit consists of hard, thick- to very thick-bedded, slightly vesicular, dark-brown basalt with moderately good splitting characteristics. The basalt in the southwest was not tested in this study and is classified on the basis of results from Hamlin Valley (FN-TR-37-e). Accessibility and minability are very good to excellent at both locations.

Other test results indicating Class I rock sources are presented in Drawing 2 and Appendix A. These units are the Cambrian Weeks and Orr limestones, the Ordovician Eureka Quartzite, and locally undifferentiated volcanics. Lithologic variability, prevents mapping these units as Class I.

4.2.2 Possible Unsuitable Concrete Aggregate/Potentially Suitble Road-Base Material - Class II

Class II crushed rock aggregate sources were identified in undifferentiated volcanic rocks located in the Needle Range and

Wah Wah Mountains. Volcanic units within the study area are typically quite variable, soft to hard, and range in composition from basaltic to rhyolitic (generally dacitic to rhyolitic). Granitic rocks are exposed locally within this unit. All samples passed abrasion but failed either soundness or alkali reactivity tests. Splitting characteristics, accessibility, and minability also vary with location.

The remainder of the rock units mapped as Class II on Drawing 2 were classified only by field visual observations. Paleozoic carbonates (Cau, Do, Ls), undifferentiated sedimentary units (Su), and undifferentiated volcanics (Vu) comprise the predominant rock types in this category.

4.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

The Weeks Limestone in northern Wah Wah Valley failed to meet Class I abrasion standards and is classified as a Class III source. This unit is hard, thin- to thick-bedded, light- and dark-gray limestone. Because this formation has passed Class I crushed rock requirements in northern Pine Valley (section 4.2.1), further field investigations will be necessary to accurately define the lithology and determine the overall classification of this formation.

5.0 CONCLUSIONS

Results of the valley-specific aggregate investigation indicate that sufficient supplies of potentially good to high quality (Class I and II) basin-fill and crushed rock aggregate materials are available within the Pine and Wah Wah valleys study area to meet construction requirements of the MX system (Drawing 2).

5.1 POTENTIAL BASIN-FILL AGGREGATE SOURCES

5.1.1 Coarse Aggregate

Major Class I coarse aggregate deposits, listed in order of potential suitability, have been identified within the following areas:

a. Alluvial fan deposits (Aafc, Aafs) in eastern Pine Valley, adjacent to the Wah Wah Mountains;

b. Older lacustrine deposits (Ao1g) in east central Wah Wah Valley; and

c. Alluvial fan (Aafs) and older lacustrine (Ao1s, Ao1g) deposits along the western side of Wah Wah Valley.

Field observations indicate additional sources of Class I coarse aggregates may be available in alluvial fan or older lacustrine deposits adjacent to the rock/alluvium contact of Class I and/or Class II crushed rock sources.

Potentially suitable Class II coarse aggregate sources are widespread in the study area. They are typically located within alluvial fan and older lacustrine deposits flanking Class I and/or Class II rock sources.

5.1.2 Fine Aggregate

While most coarse aggregate sources will supply quantities of fine aggregate either from the natural deposits or during processing, the following Class I fine aggregate (multi-type) sources were identified:

a. Alluvial fan deposits (Aafs) in east-central Pine Valley; and

b. Older lacustrine deposits (Ao1g) in east-central Wah Wah Valley.

Further field reconnaissance will be required to identify and delineate additional Class I fine aggregate sources. However, based on field observations, potential sources may exist in alluvial fan deposits derived from Class I and/or Class II rock sources and unmapped older lacustrine units.

Extensive Class II fine aggregate sources are generally found basinward of most Class I and Class II rock units.

5.2 POTENTIAL CRUSHED ROCK AGGREGATE SOURCES

Class I crushed rock sources exist in most sections of the study area. The most suitable deposits and their corresponding locations are listed as follows:

a. Precambrian quartzite and Prospect Mountain quartzite (Qtz) in San Francisco and central Wah Wah mountains;

b. Notch Peak and Guilmette formations (Cau) in Wah Wah Mountains and Needle Range;

c. Marjum Formation (Ls) in the Wah Wah Mountains and in northwestern Wah Wah Valley;

d. Fish Haven, Laketown, Sevy, and Simonson dolomites (Do) in Tunnel Spring and Wah Wah mountains and Needle Range;

e. Diorite Intrusive (Gr) in San Francisco Mountains; and

f. Basalt (Vb) in northern Wah Wah Valley and isolated basalt in southwestern part of study area.

Other rock units within the study area may provide significant quantities of Class I crushed rock (i.e., quartzite, limestone, dolomite, and undifferentiated carbonate or sedimentary units). Basalt, granite, and undifferentiated volcanic or metamorphic units exhibit greater variability, but may produce localized Class I crushed rock aggregates.

The majority of the rock units within the study area can be expected to meet minimum Class II requirements. Localized areas of Class III rock should be minimal but further investigations will be required before specific units can be designated.

6.0 BIBLIOGRAPHY

American Concrete Institute, 1977, Recommended practice for selecting proportions for normal and heavyweight concrete: American Concrete Institute, 20 p.

American Concrete Institute, 1978, Cement and concrete terminology: American Concrete Institute Publications, SP. 19 (78), 50 p.

American Public Works Assoc., 1970, Standard specifications for public works construction: Part 2 - Construction Materials, Sec. 200 Rock Materials, p. 62-70.

American Society for Testing and Materials, 1978, Annual book of ASTM standards, Part 14: Concrete and Mineral Aggregates, 814 p.

Barosh, Patrick James, 1960, Beaver Lake Mountains, Beaver County, Utah; their geology and ore deposits: Utah Geol. and Mineralogical Survey Bulletin 68, 96 p.

Bates, R. L., 1969, Geology of the industrial rocks and minerals: Dover Publications, Inc., New York, 459 p.

Best, M. G., 1976, Geology map of the Lopers Spring quadrangle, Beaver County, Utah: U.S. Geological Survey Misc. Field Studies Map MF 739.

Blanks, R., and Kennedy, H., 1955, The technology of cement and concrete, Vol. 1: John Wiley & Sons, Inc., 422 p.

Brown, L., 1959, Petrography of cement and concrete: Portland Cement Research Dept., Bulletin 111.

Conrad, Omar G., 1969, Tertiary volcanic rocks of Needles Range, Western Utah: Utah Geological and Mineralogical Survey Special Studies 29, 28 p.

Erlin, B., 1966, Methods used in petrographic studies of concrete: Portland Cement Association, Research Department Bull. 193, 17 p.

Fenneman, N. M., and D. W. Johnson, 1946, Physical divisions of the United States: U.S. Geological Survey map, scale 1:7,000,000.

Fix, P. F., and others, 1950, Ground water in the Escalante Valley, Beaver, Iron, and Washington counties, Utah: U. S. Geological Survey 27th Bicentennial Report p. 107-210.

Fugro National, Inc., 1978, Aggregate resources report, Department of Defense and Bureau of Land Mangement lands, southwestern United States: Conservation Report for SAMSO, 85 p.

__________, 1980, Aggregate Resources Report, Utah-Nevada study area: Fugro National Report FN-TR-34, 36 p.

__________, 1980, Aggregate resources study, Snake Valley, Utah-Nevada: Fugro National Report FN-TR-37-b, 47 p.

__________, 1980, Aggregate resources study, Hamlin Valley, Nevada-Utah: Fugro National Report FN-TR037-d, 44 p.

__________, 1980, Aggregate resources study, Whirlwind Valley, Utah: Fugro National Report FN-TR-37-e, 43 p.

__________, (in progress), Aggregate resources study, Tule Valley, Utah: Fugro National Report FN-TR-37-i.

__________, (in progress), Verification studies, Pine Valley, Utah: Fugro National Report FN-TR-27-PI.

__________, (in progress), Verification studies, Wah Wah Valley, Utah: Fugro National Report FN-TR-27-WA.

Gile, L. H., 1961, A classification of Ca horizons in soils in a desert region, Dona Ana County, New Mexico: Soil Sci. Soc. America Procedures, v. 25, No. 1, p. 52-61.

Hadley, D. W., 1961, Alkalai reactivity of carbonate rocks--expansion and dedolomitization: Research and Development Laboratories of the Portland Cement Association, Bulletin 139, p. 462-474.

__________, 1964, Alkalai reactivity of dolomitic carbonate rocks: Research and Development Laboratories of the Portland Cement Association, Bulletin 176, 19 p.

__________, 1968, Field and laboratory studies on the reactivity of sand-gravel aggregates: Research and Development Laboratories of the Portland Cement Association, Bulletin 221, p. 17-33.

Hayes, P. T., et al., 1977, Summary of the geology, mineral resources, engineering geology characteristics, and environmental geochemistry of east-central Utah: U. S. Geological Survey Open File Report No. 77-513, 135 p.

Heylmum, E. B., (ed.), 1963, Guidebook to the geology of southwestern Utah: Intermountain Association of Petroleum Geologists, Twelfth annual field conference, 232 p.

Hintze, L. F., 1974, Preliminary geologic map of the Conger Mountain quadrangle, Millard County, Utah: U. S. Geological Survey, MF 034.

_____________, 1974, Preliminary geologic map of the Barn quadrangle, Millard County, Utah: U. S. Geological Survey Map, MF 633.

_____________, (No date), Geologic History of Utah: Brigham Young Geology Studies, v. 20, part 3, 181 p.

_____________, 1974, Preliminary geologic map Crystal Peak quadrangel, Millard County, Utah, U. S. Geological Survey Map, MF 635.

_____________, 1974, Preliminary geologic map of the Notch Peak quadrangle, Millard County, Utah: U. S. Geological Survey Map, MF 636.

_____________, 1974, Preliminary geologic map of the Wah Wah Summit quadrangle, Millard and Beaver Counties, Utah: U. S. Geological Survey Map, MF 637.

Howard, E. L., Compiler, 1978, Geology map of the eastern Great Basin, Nevada and Utah: Terra Scan Group LTD., 3 sheets.

Ketner, K. B., 1976, Map showing high-purity quartzite in California, Nevada, Utah, Idaho and Montana: U.S. Geological Survey Map, MF-821.

Lerch, W., 1959, A cement-aggregate reaction that occurs with certain sand-gravel aggregates: Research and Development Laboratories of the Portland Cement Association, Bull. 122, p. 42-50.

McKee, E. D., and Weir, G. W., 1953, Terminology for stratification and cross-stratification in sedimentary rocks: Geological Society America Bulletin, v. 64, p. 381-389.

Mower, R. W. and R. M. Cordova, 1974, Water Resources of the Milford area, Utah, with emphasis on ground water: Utah Department National Resources Tech Pub. 43, 106 p.

Murphy, J. B., Nichols, S. L., and Schilling, J. H., No date, Rockhound map of Nevada: Nevada Bureau of Mines and Geology, special publication 1.

National Sand & Gravel Association, 1977, Compilation of ASTM standards relating to sand, gravel and concrete: NSGA Circular No. 113, NRMCA Pub. No. 137.

Pickett, G., 1956, Effect of aggregate on shrinkage of concrete and hypothesis concerning shrinkage: Portland Cement Association, Research Dept., Bull. 66, 5 p.

Powers, T. C., and Steinour, H. H., 1955, An interpretation of published researches on the alkai-aggregate reaction: Research and Development Laboratories of the Portland Cement Association, Bull. 55, Part I and II, p. 497, 785.

Roper, H., 1960, Volume changes of concrete affected by aggregate type: Portland Cement Association, Research Dept. Bull. 123, 4 p.

Synder, C. T., Hardman, George, and Zdenek, F. F., 1964, Pleistocene lakes in the Great Basin: U.S. Geol. Survey Map, I-416.

Steinour, H. H., 1960, Concrete mix water--how impure can it be? Research and Development Laboratories of the Portland Cement Association, Bull. 119, p. 33-50.

Stephens, J. C., 1974, Hydrologic reconnaissance of the Wah Wah Valley drainage basin, Millard and Beaver counties, Utah: Utah Dept. Nat. Resources Tech. Pub. 47, 53 p.

__________, 1976, Hydrologic reconnaissance of the Pine Valley drainage basin, Millard, Beaver, and Iron counties, Utah: Utah Rept. Nat. Resources Tech. Pub. 51, 38 p.

Stokes, W. L., 1963, Geologic map of northwestern Utah: Utah Geol. and Mineralogy Survey.

Stokes, W. L., and Heylmun, E. B., No Date, Outline of the geologic history and stratigraphy of Utah: Utah Geol. and Mineral. Survey, 36 p.

Stokes, W. L., and Heylmun, E. B., 1963, Tectonic history of southwestern Utah: IAPG Guidebook to the Geology of southwestern Utah, Heylmun, E. B., ed., 232 p.

Stokes, W. L., Peterson, J. A., and Picard, M. D., 1955, Correlation of Mesozoic formations of Utah: Bull. Amer. Assoc. Petrol. Geol., v. 39, No. 10, p. 2003-2019.

Travis, R. B., 1955, Classification of rocks: Quarterly of the Colorado School of Mines, v. 50, No. 1, 98 p.

U. S. Department of the Interior, 1975, Concrete Manual: Water Resources Technical Publication, 627 p.

U. S. Department of the Interior, Bureau of Mines, 1974, The Mineral Industry of Nevada.

U. S. Department of the Interior, Bureau of Reclamation, 1966, Concrete Manual: A Manual for the Control of Concrete Construction, 642 p.

__________, 1974, Earth Manual: U. S. Department of the Interior, Bureau of Reclamation, 810 p.

__________, 1975, Concrete Manual: U. S. Department of the Interior, Bureau of Reclamation, 627 p.

U. S. Geological Survey, 1969, Mineral and Water Resources of Utah: Rept. of the U.S.G.S. in cooperation with Utah Geol. and Mineral. Survey and the Utah Water and Power Board, Bull. 73, 275 p.

Utah Department of Transportation, 1979, Standard specifications for road and bridge construction: Utah Department of Transportation, 531 p.

Utah Geological Association, 1972, Plateau-basin and range transition zone, central Utah: Utah Geological Association, Publication 2.

Utah Geological Association, 1973, Geology of Milford area: Utah Geol. Assoc. Pub. 3, 95 p.

Utah Geological Society, 1963, Beryllium and uranium mineralization in western Jaub County, Utah: Guidebook to the Geology of Utah, No. 7.

Utah Geological and Mineralogical Survey, 1969, Industrial minerals of Utah, map.

Utah Geological and Mineralogical Survey, 1970, A directory of the mining industry of Utah, 1967: Utah Geol. and Mineral. Survey, Bull 84, 38 p.

__________, 1975, Utah Mineral Industry Activity 1973 and 1974: Utah Geological and Mineralogical Survey, circ. 57, 8 p.

__________, 1979, Utah mineral industry operator directory, 1979: Utah Geological and Mineralogical Survey, 69 p.

Utah State Dept. of Highways, (1965), Materials inventory Jaub County, Utah: Utah State Deptartment of Highways, 18 p.

__________, (1966), Materials inventory, Millary County, Utah: Utah State Deptartment of Highways, 22 p.

Voskuil, W. H., 1966, Selected readings in mineral economics: Nevada Bureau of Mines, Report 12, 18 p.

Waddell, J., 1976, Concrete inspection manual: International Conference of Building Officials, 332 p.

Womack, J. C., et al., 1963, Materials manual: California Highway Transporation Agency, vol. I and II.

APPENDIX A

FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA AND EXISTING TEST DATA SUMMARY TABLES - PINE AND WAH WAH VALLEYS, UTAH

EXPLANATION OF FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA

Fugro National field stations were established at locations throughout the Valley-Specific study area where detailed descriptions of potential basin-fill or rock aggregate sources were recorded (Drawing 1). All field observations and laboratory test data on samples collected at selected stations are presented in Table A-1. Data entries record conditions at specific field station locations that have been generalized in the text and Drawing 2. Detailed explanations for the column headings in Table A-1 are as follows:

Column Heading	Explanation
Map Number	This sequentially arranged numbering system was established to facilitate the labelling of Fugro National field station locations and existing data sites on Drawing 1 and to list the correlating information on Tables A-1 and A-2 in an orderly arrangement.
Field Station	Fugro National field station data are comprised of information collected during: o The Valley-Specific Aggregate Resources Study; sequentially numbered field stations were completed by two investigative teams (A and B). o The general aggregate investigation in Utah (UGS). o The Verification study in Pine and Wah Wah Valleys; trench data (PI-T or WA-T) were restricted to information below the soil horizon (1 to 2 meters).
Location	Lists major physiographic or cultural features in/or near which field stations or existing data sites are situated.

Column Heading	Explanation
Geologic Unit	Generalized basin-fill or rock geologic units at field station or existing data locations. Thirteen classifications, emphasizing age and lithologic distinctions were developed from existing geologic maps to accomodate map scale of Drawing 2.
Material Description	Except in cases where soil or rock samples were classified on laboratory results, the descriptions are based on field visual observations utilizing the Unified Soil Classification System (See Appendix C for detailed USCS information).
Field Observations	
Boulders and/or Cobbles, Percent	The estimated percentage of boulders and cobbles is based on an appraisal of the entire deposit. Cobbles have an average diameter between 3 and 12 inches (8 and 30 cm); boulders have an average diameter of 12 inches (30 cm) or more.
Gravel	Particles that will pass a 3-inch (76 mm) and are retained on No. 4 (4.75 mm) sieve.
Sand	Particles passing No. 4 sieve and retained on No. 200 (0.075 mm) sieve.
Fines	Silt or clay, soil particles passing No. 200.
Plasticity (Index)	Plasticity index is the range of water content, expressed as percentage of the weight of the oven-dried soil, through which the soil is plastic. It is defined as the liquid limit minus the plastic limit. Field classification followed standard descriptions and their ranges are as follows: None - Nonplastic (NP) (PI, 0 - 4) Low - Slightly plastic (PI, 4 - 15) Medium - Medium plastic (PI, 15 - 30) High - Highly plastic (PI, > 31)
Hardness	A field test to identify materials that are soft or poorly bonded by estimating their resistance to impact with a rock hammer; classified as either soft, moderately hard, hard, or very hard.

Column Heading	Explanation
Weathering	Changes in color, texture, strength, chemical composition or other properties of rock outcrops or rock particles due to the action of weather; field classified as either fresh or slight(ly), moderate(ly) or very weathered.
Deleterious Materials	Substances potentially detrimental to concrete performance that may be present in aggregate; includes organic impurities, low density material, (ash, vesicules, pumice, cinders), amorphous silica (opal, chert, chalcedony), volcanic glass, caliche coatings, clay coatings, mica, gypsum, pyrite, chlorite, and friable materials, also, aggregate that may react chemically or be affected chemically by other external influences.
Laboratory Test Data	
Sieve Analysis (ASTM C 136)	The determination of the proportions of particles lying within certain size ranges in granular material by separation on sieves of different size openings; 3-inch, 1 1/2-inch, 3/4-inch, 3/8-inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100 and No. 200.
No. 8, No. 16, No. 30, No. 50	Asterisked entries used No. 10, No. 20, No. 40, and No. 60 sieves, respectively.
Abrasion Test (ASTM C 131)	A method for testing abrasion resistance of an aggregate by placing a specified amount in a steel drum (the Los Angeles testing machine), rotating it 500 times, and determing the material worn away.
Soundness Test (ASTM C 88) CA, FA	CA = Coarse Aggregate FA = Fine Agregate The testing of aggregates to determine their resistance to disintegration by saturated solutions of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

Column Heading	Explanation
Specific Gravity and Absorption (ASTM C 127 and 128)	Methods to determine the Bulk Specific Gravity, Bulk SSD Specific Gravity (Saturated - Surface Dry Basis), and Apparent Specific Gravity and Absorption as defined in ASTM E12-70 and ASTM C 125, respectively.
Alkali Reactivity (ASTM C 289)	This method covers chemical determination of the potential reactivity of an aggregate with alkalies in portland cement concrete as indicated by the amount of reaction during 24 hours at 80°C between 1 N sodium hydroxide solution and aggregate that has been crushed and sieved to pass a No. 50 (300- m) sieve and be retained on a No. 100 (150- m) sieve.
Aggregate Use	I = Class I; potentially suitable concrete aggregate and road-base material source. II = Class II; possibly unsuitable concrete aggregate/potentially suitable road-base material source. III = Class III; unsuitable concrete aggregate or road base material source. c = coarse aggregate f = fine aggregate f/c = fine and coarse aggregate cr = crushed rock All sources not specifically identified as Class I, II, or III from the abrasion, soundness, or alkali reactivity tests or the content of clay- and silt-sized particles, are designated as Class II sources.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUT MATERIAL THAN CO PERCE	
							GRAVEL	SAND
1	PI-A1	Pine Valley	Aafs	Gravelly Sand	SP-SM			
2	PI-A2	Wah Wah Mountains	Ls	Limestone				
3	PI-A3	Wah Wah Mountains	Ls	Limestone				
4	PI-A4	Pine Valley	Aafs	Sandy Gravel	GP-GM			
5	PI-A5	Pine Valley	Vu	Rhyodacite Ignimbrite				
6	PI-A6	Pine Valley	Aafs	Sandy Gravel with Boulders	GW			
	PI-A7	Needle Range	Qtz	Quartzite				
8	PI-A8	Needle Range	Vu	Dacite Ash-flow Tuff				
9	PI-A9	Pine Valley	Aafs	Gravelly Sand	SP	0	30	65
10	PI-A10	Pine Valley	Aafs	Sandy Gravel	GP-GM			
11	PI-A11	Pine Valley	Aafs	Sandy Gravel	GW-GM			
12	PI-A12	Wah Wah Mountains	Vu	Rhyolite flow				
13	PI-A13	Pine Valley	Aals	Silty Sand	SM			
14	PI-A14	Pine Valley	Do	Dolomite				
15	PI-A15	Pine Valley	Aafs	Silty Gravel with Sand	GM			

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (ASTM C							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
			None			Chert		100	94.5	83.7	71.7	64.4	58.3	48.2
				Hard	Slight	Shale Interbeds								
				Hard	Slight	None								
			None			Caliche Coatings	100	94.3	86.3	67.3	42.2	28.6	20.1	15.4
				Mod. Hard	Mod.	Volcanic Glass, Mica								
			None			Caliche Coatings	75.0	57.9	45.5	33.6	24.3	17.0	11.3	8.3
				Very Hard	Slight	None								
				Mod. Hard	Mod.	Volcanic Glass, Biotite								
30	65	5	None			Caliche Coatings								
			None			Volcanic Glass	100	90.5	77.3	64.4	52.4	46.4	37.9	28.5
			Low to Medium			Volcanic Glass, Volcanic Ash	90.7	84.9	76.4	65.6	53.8	44.3	32.4	22.7
				Hard	Slight	Volcanic Glass, Ash, Vesicles								
			None to Low			Volcanic Glass		100	99.2	97.5	91.2	81.8	62.2	35.6
				Hard	Slight	None								
			None			Caliche Coatings		100	94.7	82.2	61.1	48.3	39.1	34.3

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LABORATORY TEST DATA

STM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289)	
							COARSE AGGREGATE				FINE AGGREGATE					
							SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
O. 0	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	FA
.2	32.4	10.8	6.5			11.7						2.57		2.8		Potentia Deleteri
				30.5	1.6			2.75	0.5						Innocuous	
				37.1	9.2											
.4	11.9	9.1	6.5	27.9	1.1	9.7		2.69	1.0						Potentially Deleterious	Deleteri
				47.4	25.1											
3	6.2	4.0	2.0	32.6	4.0	13.7		2.80	0.8			2.64		2.2	Innocuous	Innocuou
				32.9	2.6											
				24.0	9.1										Deleterious	
.5	19.3	13.3	9.3	35.0	26.4	29.2										
.7	15.6	12.2	10.1	38.2	26.7	31.0										
				23.4	5.0										Deleterious	
.6	26.2	18.0	12.5			46.4										
				23.5	0.6			2.82	0.6						Innocuous	
.3	31.2	27.9	23.8	21.6	4.1	22.0										

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BSORPTION 128) FINE AGGREGATE			ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
FIC GRAVITY		PERCENT ABSORPTION	CA	FA	
BULK SSD	APPAR-ENT				
2.57		2.8	Innocuous	Potentially Deleterious	If Icr
					Icr
			Potentially Deleterious	Deleterious	Ic IIf IIcr
2.64		2.2	Innocuous	Innocuous	Ic/f
					Icr
			Deleterious		IIcr
					IIc/f
					IIc/f
					IIc/f
			Deleterious		IIcr
					IIf
			Innocuous		Icr
					Ic IIf

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

FUGRO NATIONAL, INC.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUT MATERIAL THAN CO PERCE	
							GRAVEL	SAND
16	PI-A16	Escalante Desert	Vb	Basalt(?) Highly Altered				
17	PI-A17	Escalante Desert	Au	Gravelly Sand	SW-SM			
18	PI-A18	Escalante Desert	Au	Gravelly Sand	SP	3	40	60
19	PI-A19	Pine Valley	Aafs	Sandy Gravel	GP	10	65	30
20	PI-A20	Pine Valley	Aafs	Sandy Gravel	GP-GM	5	60	30
21	PI-A21	Pine Valley	Aafs	Sandy Gravel	GW-GM			
22	PI-A22	Pine Valley	Aaf	Silty Gravel with Sand	GM			
23	PI-A23	Pine Valley	Aaf	Gravelly Sand	SP	T	45	55
24	PI-A24	Pine Valley	Aafs	Sandy Gravel	GP-GM			
25	PI-A25	Pine Valley	Aafs	Sandy Gravel	GW			
26	PI-B1	Pine Valley	Qtz	Quartzite				
27	PI-B2	Pine Valley	Aafs	Sandy Gravel	GP-GM			
28	PI-B3	Pine Valley	Aafs	Sandy Gravel	GP	7	65	30
29	PI-B4	Pine Valley	Aafs	Sandy Gravel	GP-GM			
30	PI-B5	Pine Valley	Aafs	Sandy Gravel	GP-GM			

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING (ASTM							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS									
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30	
				Hard to Very Hard	Slight	Amorphous Silica, Low Density Material (<5%)									
			None			Low Density Volcanic Clasts	96.6	89.3	85.2	78.3	68.1	56.8	39.5	24.6	
40	60	T	None			Low Density Volcanic Clasts									
65	30	5	None			Caliche Coatings									
60	30	10	None			Caliche Coatings									
			None				100	88.1	78.4	61.1	43.6	30.9	22.6	17.1	
			None			Caliche Coatings	100	96.3	90.0	72.3	49.8	35.3	26.2	21.6	
45	55	0	None			Chalcedony(?), Volcanic Glass									
			None			Caliche Coatings	98.2	92.8	74.9	49.9	33.8	25.0	24.2	16.4	
			None			Caliche Coatings	96.2	84.4	61.1	45.3	34.7	28.5	24.1	19.4	
				Hard	Slight	None									
			None			5% Low Density Sandstone	100	93.4	73.9	52.2	37.0	29.1	23.4	19.3	
65	30	5	None			Caliche Coatings									
			None			Caliche Coatings & Nodules	89.6	73.8	62.6	53.0	42.9	34.6	28.0	22.3	
			None			<5% Low Density Material	88.0	58.9	40.7	35.5	29.6	27.5	25.3	20.3	

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LABORATORY TEST DATA

NG (ASTM C 136)					ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKAL REACTIV (ASTM C	
								COARSE AGGREGATE				FINE AGGREGATE					
								SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
.	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	
.5	24.6	13.8	9.0	7.0	30.7	11.3	28.0										
.6	17.1	12.8	9.0	6.0	24.6	2.0	21.2										
.2	21.6	18.9	17.0	14.3	20.5	1.4	5.8										
.2	16.4	14.6	13.4	11.7	32.1	1.6	12.2		2.75		0.7		2.62		2.9	Potentially Deleterious	In
.1	19.4	12.1	7.2	4.8	26.9	4.9	17.0										
					30.4	0.5											
.4	19.3	15.7	12.8	9.7	25.5	0.9	10.3		2.71		0.7		2.61		2.8	Innocuous	In
0	22.3	15.4	10.7	7.8	28.7	6.7	26.1		2.60		1.9					Innocuous	
3	20.3	11.8	7.9	6.5	28.7	2.0	8.5									Deleterious	D

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ABSORPTION (C 128)			ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
FINE AGGREGATE					
CIFIC GRAVITY		PERCENT ABSORPTION			
BULK SSD	APPARENT		CA	FA	
					IIcr
					Ic
					IIf
					IIc f
					IIc f
					IIc f
					Ic
					IIf
					Ic f
					IIc f
2.62		2.9	Potentially Deleterious	Innocuous	Ic f
					Ic
					IIf
					Icr
2.61		2.8	Innocuous	Innocuous	Ic f
					IIc f
			Innocuous		Ic
					IIf
			Deleterious	Deleterious	IIc/f

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

FUGRO NATIONAL, INC.

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRI[illegible] MATERI[illegible] THAN [illegible] PE[illegible] GRAVEL	
31	PI-B6	Wah Wah Mountains	Qtz	Quartzite				
32	PI-B7	Pine Valley	Aafs	Silty Sand with Gravel	GM			
33	BV-A22	Pine Valley	Aafs	Sandy Gravel	GP			
34	BV-B2	Pine Valley	Aafs	Gravelly Sand	SP	5	35	6[illegible]
35	WA-A1	Wah Wah Valley	Aolq	Gravelly Sand	SP			
36	WA-A2	San Francisco Mountains	Qtz	Quartzite				
37	WA-A3	Wah Wah Valley	Aols	Sandy Gravel	GP-GM			
38	WA-A4	Wah Wah Valley	Aols	Sandy Gravel	GP			
39	WA-A5	San Francisco Mountains	Gr	Diorite				
40	WA-A6	Wah Wah Valley	Aafs	Sandy Gravel	GW-GM			
41	WA-A7	Willow Creek	Aafs	Gravelly Sand	SP	5	45	55
42	WA-A8	Wah Wah Valley	Aafs	Gravelly Sand	SW-SM			
43	WA-A9	Wah Wah Valley	Vu	Andesitic Ignimbrite				

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING (AST							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS									
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
				Hard to Very Hard	Slight	None								
			Low to Med.			Caliche Coatings	98.5	91.8	76.9	58.7	45.7	41.6	39.1	38.2
			None to Low			Volcanic Glass	100	87.6	68.1	56.3	47.3	42.5	35.5	23.6
35	65	T	None			Chert, Caliche Coatings								
			None			Caliche Coatings	100	99.1	81.4	67.8	56.1	47.1	38.9	26.5
				Very Hard	Slight	None								
			None			Caliche Coatings	100	90.4	77.1	49.7	23.7	13.2	11.0	10.2
			None			Caliche Coatings	100	96.1	64.1	40.2	28.7	27.5	27.1	26.6
				Hard	Slight									
			None			Low Density Volcanics	97.0	85.4	72.7	61.1	47.1	36.7	25.7	17.9
45	55	T	None			Caliche Coatings, Low Density Volc.								
			None			Low Density Volcanics		100	97.5	88.2	64.5	38.9	21.3	12.2
				Mod.Hard to Hard	Slight	Low Density Volcanics, Mica								

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LABORATORY TEST DATA

(ASTM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289)	
							COARSE AGGREGATE				FINE AGGREGATE					
							SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	F
38.2	36.9	32.1	23.6	23.2	2.8	28.0		2.71		2.1					Innocuous	
23.6	11.1	3.3	1.0	38.9	18.1	33.7										
26.5	10.6	3.4	1.6	30.3	4.5	11.4		2.71		0.9		2.60		2.1	Innocuous	Innoc
				29.6	2.4											
10.2	9.0	7.4	6.1	18.5	1.6	22.7		2.65		0.7					Innocuous	
26.6	18.4	7.8	4.2	24.5	3.5	10.8		2.63		0.8		2.64		1.0	Innocuous	Innoc
				30.5	6.7			2.71		0.8					Innocuous	
17.9	12.5	8.9	6.6	30.9	22.6	36.5										
12.2	8.1	6.7	6.2		26.5	27.2										
				24.7	3.6										Potentially Deleterious	

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GRAVITY AND ABSORPTION (M C 127 AND C 128)						ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
ATE		FINE AGGREGATE						
		SPECIFIC GRAVITY						
	PERCENT ABSORPTION	BULK	BULK SSD	APPARENT	PERCENT ABSORPTION	CA	FA	
								IIcr
	2.1					Innocuous		Ic IIf
								IIc/f
								IIc/f
	0.9		2.60		2.1	Innocuous	Innocuous	Ic/f
								Icr
	0.7					Innocuous		Ic IIf
	0.8		2.64		1.0	Innocuous	Innocuous	Ic/f
	0.8					Innocuous		Icr
								IIc/f
								IIc/f
								IIc/f
						Potentially Deleterious		Icr

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

FUGRO NATIONAL, INC.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBU[illegible] MATERIAL[illegible] THAN CO[illegible] PERC[illegible]	
							GRAVEL	SAND
44	WA-A10	Wah Wah Mountains	Su	Limestone				
45	WA-A11	Escalante Desert	Au	Sandy Gravel	GW			
46	WA-A12	Escalante Desert	Au	Gravelly Sand	SP	T	25	75
47	WA-A13	Escalante Desert	Au	Gravelly Sand	SP	3	40	60
48	WA-A14	Wah Wah Mountains	Ls	Dolomite				
49	WA-A15	San Francisco Mountains	Qtz	Quartzite				
50	WA-A16	San Francisco Mountains	Au	Gravelly Sand	SP	3	30	65
51	WA-A17	Wah Wah Valley	Aols	Sandy Gravel	GP			
52	WA-A18	Wah Wah Valley	Aolg	Sandy Gravel	GW			
53	WA-A19	Wah Wah Valley	Aafs	Sandy Gravel with Boulders	GP/SP	20	50	50
54	WA-A20	Wah Wah Valley	Aafs	Sandy Gravel	GP-GM	10	60	[illegible]
55	WA-A21	Brown Knoll	Vb	Basalt				
56	WA-A22	Wah Wah Valley	Aafs	Sandy Gravel	GP/SP	10	50	[illegible]

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (ASTM							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
				Hard	Slight	Calcite Veins								
			None			<5% Chert,<15% Low Density Volcanics		100	88.5	69.9	50.9	37.3	24.3	18.4
25	75	0	None			Low Density Volcanics								
40	60	T	None			Low Density Volcanics								
				Hard to Very Hard	Slight	Caliche Coatings								
				Very Hard	Slight	None								
30	65	5	None			Low Density Volcanics								
			None			1-2% Low Density Volcanics	51.7	39.9	24.0	13.6	11.6			
			None				97.2	89.0	64.0	41.5	32.4	28.9	20.6	7.9
50	50	T	None			Shale								
60	30	10	None to Low			Caliche Coatings								
				Very Hard	Fresh to Slight	Vesicles, Olivine, Obsidian								
50	50	T	None	Mod.Hard to Hard	Slight to Mod.	Volcanic Ash, Tuff & Glass								

LABORATORY TEST DATA

(ASTM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289	
							COARSE AGGREGATE				FINE AGGREGATE					
							SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		CA	F
18.4	11.9	7.8	4.5	35.8	5.7	26.7										
				23.4	0.7											
				25.6	1.7											
				23.9	0.7										Deleterious	
7.9	2.5	1.7	1.3	24.3	1.6	6.4		2.66		0.5		2.64		1.1	Innocuous	Inno
				24.3	0.4			2.47		3.5					Innocuous	

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...ON		ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
...EGATE ...VITY				
...PPAR-ENT	PERCENT ABSORPTION	CA	FA	
				IIcr
				Ic IIf
				IIf
				IIc/f
				Icr
				Icr
				IIc/f
		Deleterious		IIcr
	1.1	Innocuous	Innocuous	Ic/f
				IIc/f
				IIc/f
		Innocuous		Icr
				IIc/f

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

FUGRO NATIONAL, INC.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES PERCENT	[illegible] MATERIAL THAN C[illegible] PERC[illegible]	
							GRAVEL	SAND
57	WA-A23	Wah Wah Valley	Aols	Silty Sand with Gravel	GW-GM			
58	WA-B6	Wah Wah Valley	Ls	Limestone				
59	WA-B7	Lawson Cove	Aafs	Sandy Gravel	GW			
60	WA-B8	Lawson Cove	Aafs	Sandy Gravel	GP-GM			
61	WA-B10	Lawson Cove	Ls	Limestone				
62	WA-B11	Lawson Cove	Aafs	Sandy Gravel/ Gravelly Sand	GP/SP	2	50	50
63	WA-B12	Wah Wah Valley	Aafs	Sandy Gravel	GP-GM			
64	WA-B13	Wah Wah Mountains	Vu	Granadiorite				
65	WA-B14	Wah Wah Valley	Aafs	Sandy Gravel	GP-GM			
66	WA-B15	Wah Wah Valley	Aafs	Sandy Gravel	GW-GM			
67	WA-B16	Wah Wah Valley	Aafs	Sandy Gravel	GP-GM			
68	WA-B17	Wah Wah Valley	Aafs	Sandy Gravel	GP-GM			
69	WA-B18	Escalante Desert	Au	Gravelly Sand	SP	T	35	65

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (ASTM							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
			None				100	93.3	87.5	76.0	51.7	37.7	21.8	16.6
				Hard	Slight	Calcite Veins								
			None			Caliche Nodules	100	98.9	93.6	78.5	46.3	30.4	17.5	11.5
			None			None	100	94.0	77.9	58.5	38.7	26.6	19.4	14.9
				Hard		Chert Nodules & Lenses								
50	50	T	None			Caliche Coatings (Stage III)								
			None			Caliche Coatings	100	96.4	76.1	57.1	40.5	31.6	24.9	20.4
				Hard to Very Hard		Volcanic Glass, Mica								
			None			10% caliche, <5% Shaley Sandstone	93.6	84.4	68.9	54.0	43.6	37.9	33.2	28.2
			None			Caliche Coatings	100	92.3	70.7	55.4	43.8	33.4	25.2	19.2
			None			Caliche Nodules, <5% Shaley Sandstone	100	83.9	68.9	57.7	44.9	37.2	30.4	25.0
			None			<5% Caliche Nodules, <5%Chert	100	91.4	78.6	64.5	49.7	40.5	31.3	23.0
35	65	T	None			Mica, Volcanic Glass, 12% Shaley Sandstone								

LABORATORY TEST DATA

(ASTM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289)	
							COARSE AGGREGATE				FINE AGGREGATE					
							SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	F
16.6	11.9	9.2	7.5	29.9	3.2	19.6										
				55.0												
11.5	8.2	5.8	3.9	31.1	4.0	27.3										
14.9	11.5	8.6	5.3	25.5	4.1	26.5										
				25.0	0.7			2.85		0.3					Innocuous	
20.4	16.5	13.7	11.1	35.1	2.5	21.7										
				40.4	6.7										Deleterious	
28.2	21.2	13.9	8.[illegible]	42.1	6.3	33.6		2.64		1.3					Innocuous	
19.2	13.9	10.6	7.0	29.1	1.9	18.7		2.73		0.9					Innocuous	
25.0	18.7	12.1	6.8	22.8	2.6	28.4		2.80		0.5					Innocuous	
23.0	14.4	8.4	5.3	30.3	11.6	19.0									Deleterious	

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D ABSORPTION (C 128) FINE AGGREGATE				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
ECIFIC GRAVITY			PERCENT ABSORPTION			
LK	BULK SSD	APPAR-ENT		CA	FA	
						Ic IIf
						IIIcr
						Ic IIf
						Ic IIf
				Innocuous		Icr
						IIc/f
						Ic IIf
				Deleterious		IIcr
				Innocuous		Ic IIf
				Innocuous		Ic IIf
				Innocuous		Ic IIf
				Deleterious		IIc/f
						IIc/f

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

FUGRO NATIONAL, INC.

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBUT MATERIAL THAN CO PERCE	
							GRAVEL	SAND
70	WA-B19	Big Wash	Au	Gravelly Sand	SP	T	15	85
71	WA-B20	San Francis-co Mountains	Au	Gravelly Sand	SP/SW	T	30	70
72	WW-B7	Wah Wah Valley	Aols	Silty Sand with Gravel	SM	T	30	40
73	UGS-A18	Wah Wah Valley	Aols	Gravelly Sand	SM	0	15	70
74	UGS-A45	Wah Wah Valley	Aols	Sandy Gravel	GW			
75	UGS-A46	Star Range	Gr	Granite				
76	UGS-A48	Wah Wah Mountains	Ls	Limestone				
77	UGS-A49	Pine Valley	Aaf	Sandy Gravel	GP	T	50	45
78	UGS-A50	Pine Valley	Aafs	Sandy Gravel	GP	T	70	30
79	UGS-A54	Lawson Cove	Ls	Limestone				
80	UGS-A55	Pine Valley	Vu	Latite Ignimbrite				
81	UGS-A56	Pine Valley	Aafs	Gravelly Sand	SP	0	15	85
82	UGS-A57	Pine Valley	Aafs	Gravelly Sand	SP	5	35	65

FIELD OBSERVATIONS														
TRIBUTION OF TERIAL FINER HAN COBBLES, PERCENT		PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	SIEVE ANALYSIS, PERCENT PASSING (ASTM C 1								
SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50
85	T	None			Caliche Coatings									
70	T	None			Caliche Coatings									
40	30	None			Clay, Caliche Coatings									
70	15	Low			Caliche Coatings									
		None			5% Glass or Altered Volcanics	100	87.0	70.2	54.1	42.1	33.0	26.0	20.2	6.
			Very Hard	Fresh	5% Epidote, Zeolites									
			Very Hard	Slight	Caliche Along Joints(Calcite ?)									
45	5	Low to None			5% Chert, 10% Volcanic Glass									
30	0	None			None									
			Very Hard	Slight	Chert									
			Mod. Hard	Mod.	Chalcedony, Volcanics Glass(?), Low Density Material									
85	0	None			>70% Volcanic Glass , Low Density Material									
65	T	None												

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LABORATORY TEST DATA

(…TM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289)	
							COARSE AGGREGATE				FINE AGGREGATE					
							SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
…	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		CA	FA
.2	6.6	2.1	1.0	22.2	1.08	11.3										

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D ABSORPTION D C 128)				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
FINE AGGREGATE						
ECIFIC GRAVITY			PERCENT ABSORPTION			
LK	BULK SSD	APPAR-ENT		CA	FA	
						IIf
						IIc/f
						IIf/c
						IIf
						Ic/f
						IIcr
						IIcr
						IIc/f
						IIc/f
						IIcr
						IIcr
						IIf
						IIc/f

FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA, PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

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FUGRO NATIONAL, INC.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRI… MATER… THAN … PE…
							GRAVEL
83	UGS-A58	Pine Valley	Au	Silty Sand	SP	0	T
84	UGS-A59	Pine Valley	Aafs	Sandy Gravel	GP	5	65
85	UGS-A60	Wah Wah Mountains	Qtz	Quartzite			
86	UGS-A61	Needle Range	Vu	Rhyodacite			
87	UGS-A64	Escalante Desert	Vu	Tuff			
88	UGS-A66	Escalante Desert	Vb	Volcanic Flow Breccia			
89	UGS-A67	Escalante Desert	Au	Sandy Gravel	GP	5	60
90	UGS-B31	San Francis-co Mountains	Qtz	Quartzite			
91	UGS-B32	Wah Wah Valley	Aafs	Sandy Gravel	GW	10	65
92	UGS-B33	Squaw Peak	Vu	Porphyritic Andesite			
93	UGS-B34	Wah Wah Mountains	Vu	Basalt(?)			
94	UGS-B39	Sevier Desert	Aols	Sandy Gravel	GP	10	65
95	UGS-B41	Escalante Desert	Au	Gravelly Sand	SP	T	30
96	UGS-B42	Escalante Desert	Vu	Andesite			

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (ASTM							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
T	95	5	None			%5 Chalcedony								
65	30	5	None			None								
				Very Hard	Fresh	None								
				Soft	Highly	5% Volcanic Glass								
				Mod. Hard	Mod.	>70% Volcanic Glass								
				Mod. Hard	Slight	>50% Low Density Materials								
60	40	T	None			>50% Altered Volcanics & Low Density Material								
				Very Hard	Slight	None								
65	35	0	None			Caliche Coatings								
				Hard	Mod.	None								
				Hard	Slight	15% Vesicles								
65	35	T	None			Caliche Coatings								
30	70	T	None			10% Low Density Material								
				Hard	Slight	15% Low Density Material								

LABORATORY TEST DATA

NG (ASTM C 136)					ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVE (ASTM C 2	
								COARSE AGGREGATE				FINE AGGREGATE					
								SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
.	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS		BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	
						CA	FA										

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...TION						AGGREGATE USE
...GGREGATE			ALKALI REACTIVITY (ASTM C 289)			
...RAVITY						
	APPAR-ENT	PERCENT ABSORPTION	CA	FA		
						IIf
						IIc/f
						IIcr
						IIcr
						IIcr
						IIcr
						IIc/f
						IIcr
						IIc/f
						IIcr
						IIcr
						IIc/f
						IIc/f
						IIcr

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

FUGRO NATIONAL, INC.

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRI MATERIA THAN C PER GRAVEL
97	UGS-B43	Escalante Desert	Su	Sandstone			
98	UGS-B44	Escalante Desert	Vu	Ignimbrite			
99	UGS-B45	Escalante Desert	Au	Gravelly Sand	SP	5	25
100	UGS-B53	Wah Wah Valley	Aols	Sandy Gravel	GW	T	60
101	UGS-B54	Wah Wah Mountains	Vu	Latite			
102	UGS-B57	San Francisco Mountains	Au	Silty Sand	SM	0	10
103	UGS-B58	Beaver Lake Mountains	Au	Gravelly Sand	SP	5	40
104	UGS-B60	Pine Valley	Aafs	Sandy Gravel	GW	20	60
105	UGS-B61	Wah Wah Mountains	Cau	Limestone			
106	UGS-B62	Pine Valley	Aafs	Gravelly Sand	SW	15	45
107	UGS-B63	Wah Wah Valley	Aafs	Gravelly Sand	SW	T	35
108	UGS-B65	Wah Wah Valley	Vu	Rhyolite			
109	UGS-B66	Escalante Desert	Vu	Rhyolite			

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (ASTM C								
STRIBUTION OF TERIAL FINER HAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS									
	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30	N 5
				Mod. Hard	Slight	Iron Sulfides, Friable Material									
				Soft	Mod.	15% Chalcedony, Volcanic Glass									
25	75	T	None			5% Chert, Low Density Material									
60	40	0	None			5% Chert, Caliche Coatings									
				Hard	Slight	5% Volcanic Glass									
10	60	30	None			Caliche Coatings									
40	60	T	None			Caliche Coatings									
60	40	T	None			Caliche Coatings									
				Hard	Slight	None									
45	50	5	None			<5% Low Density Intermediate Volcanics									
35	60	5	None			<5% Low Density Volcanics									
				Hard	Slight	10% Vesicular Low Density Material									
				Hard	Slight	10% Volcanic Glass									

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LABORATORY TEST DATA

...TM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289)	
							COARSE AGGREGATE				FINE AGGREGATE					
					PERCENT LOSS		SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
.	NO. 50	NO. 100	NO. 200	PERCENT WEAR	CA	FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	FA

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...ORPTION ...8)			ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
...E AGGREGATE					
...C GRAVITY		PERCENT ABSORPTION			
...ULK ...SD	APPAR-ENT		CA	FA	
					IIcr
					IIcr
					IIf
					IIc/f
					IIcr
					IIf
					IIc/c
					IIc/f
					IIcr
					IIc/f
					IIc/f
					IIcr
					IIcr

FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

FUGRO NATIONAL, INC.

4

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTRIBU… MATERIAL… THAN C… PERC…	
							GRAVEL	SAND
110	UGS-B67	Escalante Desert	Au	Gravelly Sand	SP-SM	10	30	60
111	PV-T-1	Pine Valley	Aafs	Coarse-Fine Sand	SP			
112	PV-T-4	Pine Valley	Aafs	Sandy Gravel	GP-GM			
113	PV-T-10	Pine Valley	Aafs	Silty Sand	SM			
114	PV-T-12	Pine Valley	Aafs	Silty Sand	SW-SM			
115	PV-T-13	Pine Valley	Aafs	Silty Sand	SW-SM			
116	PV-T-14	Pine Valley	Aafs	Coarse-Medium Sand	SP			
117	PV-T-16	Pine Valley	Aafs	Silty Sandy Gravel	GP-GM			
118	PV-T-17	Pine Valley	Aafs	Sandy Gravel	GP-GM			
119	PV-T-19	Pine Valley	Aafs	Silty Gravel	GM			
120	WA-T-2	Wah Wah Valley	Aafs	Sandy Gravel	GP-GM			
121	WA-T-3	Wah Wah Valley	Aafs	Silty Sand	SM			
122	WA-T-7	Wah Wah Valley	Aafs	Coarse-Fine Sand	SW			
123	WA-T-8	Wah Wah Valley	Aafs	Silty Sand	SP-SM			
124	WA-T-9	Wah Wah Valley	Aafs	Coarse-Fine Sand	SW			
125	WA-T-14	Wah Wah Valley	Aafs	Sandy Gravel	GW-GM			

FIELD OBSERVATIONS														
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	SIEVE ANALYSIS PERCENT PASSING (ASTM							
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
30	60	10	Low			None								
								100	86.0	73.4	62.0	*45.4	*28.5	*16.5
								100	73.6	36.5	22.5	*17.4	*15.0	*13.7
									100	91.3	86.3	*76.7	*62.4	*48.0
									100	93.1	84.8	*68.0	*40.6	*22.2
								100	98.0	79.7	62.4	*41.2	*26.8	*19.0
							100	94.5	86.7	71.4	58.2	*43.0	*23.8	*10.8
								100	80.1	53.0	32.5	*23.9	*19.7	*16.6
							100	89.9	40.5	31.8	26.2	*21.5	*15.9	*12.0
								100	74.5	66.8	56.6	*47.1	*35.4	*27.0
								100	68.0	47.1	36.1	*26.7	*20.4	*16.0
										100	97.4	*88.2	*68.2	*46.2
									100	78.4	60.5	*41.3	*21.4	*10.2
									100	90.0	77.9	*59.0	*38.4	*24.6
								100	97.8	86.9	60.2	*33.8	*19.4	*12.9
							100	82.0	73.4	56.3	41.5	*26.9	*17.8	*13.3

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LABORATORY TEST DATA

G (ASTM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289	
							COARSE AGGREGATE				FINE AGGREGATE					
							SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA	F
*16.5	*9.5	5.5	3.4													
*13.7	*12.5	11.3	9.4													
*48.0	*34.1	21.7	12.5													
*22.2	*13.1	8.3	6.4													
*19.0	*14.5	11.5	9.4													
*10.8	*4.1	1.9	1.1													
*16.6	*13.8	11.8	10.2													
*12.0	*9.5	7.5	5.3													
*27.0	*22.2	19.4	17.0													
*16.0	*12.5	9.6	7.3													
*46.2	*31.5	22.7	14.3													
*10.2	*6.1	4.3	3.6													
*24.6	*17.9	14.5	12.0													
*12.9	*9.1	6.6	4.8													
*13.3	*10.4	8.1	5.7													

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...AND ABSORPTION ...AND C 128)				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
FINE AGGREGATE						
SPECIFIC GRAVITY			PERCENT ABSORPTION			
BULK	BULK SSD	APPAR-ENT		CA	FA	
						IIc/f
						IIc/f
						IIc
						IIf
						IIf
						IIc/f
						IIc/f
						IIc
						IIc
						IIcf
						IIc
						IIf
						IIc/f
						IIf
						IIc/f
						IIc/f

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION

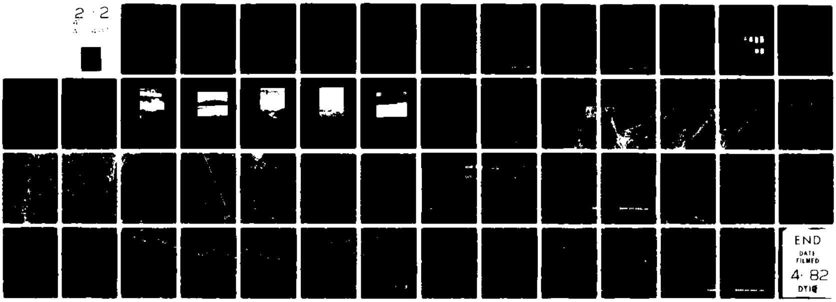
DEPARTMENT OF THE AIR FORCE — BMO

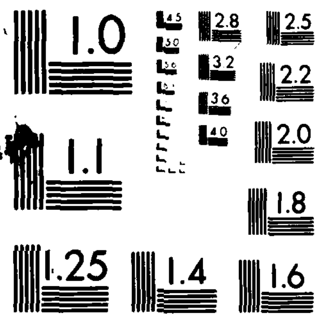
TABLE A-1

FUGRO NATIONAL, INC.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTR MATER THAN P
							GRAVEL
126	WA-T-15	Wah Wah Valley	Aols	Clayey Silt	ML		
127	WA-T-16	Wah Wah Valley	Aols	Silty Clay	CH		
128	WA-T-18	Wah Wah Valley	Aafs	Clayey Silt	ML		

AD-A112 407 FUGRO NATIONAL INC LONG BEACH CA F/G 8/7
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. AGGREGATE RES--ETC(U)
FEB 81 F04704-80-C-0006
UNCLASSIFIED FN-TR-37-6 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (ASTM							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS								
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
										100	99.8	*99.4	*97.6	*94.8
														*100
									100	95.7	91.0	*86.3	*83.5	*79.9

2

LABORATORY TEST DATA

C 136)			ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289)	
						COARSE AGGREGATE				FINE AGGREGATE					
						SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		CA	FA
*89.7	72.0	52.6													
*99.9	99.8	99.8													
*74.3	66.3	54.6													

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...ABSORPTION (...C 128) ...FINE AGGREGATE ...CIFIC GRAVITY				ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
...	BULK SSD	APPARENT	PERCENT ABSORPTION	CA	FA	
						IIf
						III
						IIf

FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A-1

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FUGRO NATIONAL, INC.

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EXPLANATION OF EXISTING DATA

Existing data pertaining to aggregates were extracted from the Utah State Department of Highways' Materials Inventory county reports. These reports are compilations of avaiable site data from existing files and records and are intended to accurately locate, investigate, and catalog materials needed for highway construction. Explanations for column headings which appear in Table A-2, that have not been previously discussed in Table A-1, are given below:

Column Heading	Explanation
Site Number	Utah State Department of Highways pit or site number. Locations correspond to map numbers listed on this table and placed on Drawing 2.
Material Description USCS Symbol	To maintain conformity within the study, the Utah State Department of Highways classification system (A.A.S.H.O.) was converted to the Unified Soil Classification System (USCS) utilizing the sieve analyses' size distribution and the plasticity indices.
Sieve Analysis	The size distribution of fine and coarse aggregate samples was determined by sieving. In some samples, particles greater than 1 inch in size (>1 inch) were crushed to 1 inch maximum size and remixed with the remaining sample before sieving. In these cases, data entries under 1 inch are 100 percent, preceeded by before crushing percentages.
No. 10, No. 40	Samples tested after mid-1963 used No. 8 and No. 50 sieves, respectively. These entries are marked with asterisks.
Soundness Test	The testing of aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action,

Column Heading	Explanation
Soundness Test (cont.)	particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

MAP NUMBER	SITE NUMBER	DATA SOURCE	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION
129	14126	USDH Millard Co.	Pine Valley	Aaf	Gravelly Sand
130	14127	USDH Millard Co.	Pine Valley	Aals	Silty Sand with Grav
131	14128	USDH Millard Co.	Pine Valley	Aafs	Gravelly Sand
132	01067	USDH Beaver Co.	Pine Valley	Aols	Gravelly Sand
133	01066	USDH Beaver Co.	Pine Valley	Aols	Gravelly Sand
134	01065	USDH Beaver Co.	Pine Valley	Aafs	Silty Sand with Grav
135	01064	USDH Beaver Co.	Pine Valley	Aalg	Silty Gravel with Sa
136	01063	USDH Beaver Co.	Pine Valley	Aafs	Silty Sand
137	01062	USDH Beaver Co.	Wah Wah Valley	Aafs	Sandy Gravel with Si
138	01061	USDH Beaver Co.	Wah Wah Valley	Aafs	Sandy Gravel
139	01060	USDH Beaver Co.	Wah Wah Valley	Aafs	Silty Sand with Grav
140	01059	USDH Beaver Co.	Wah Wah Valley	Aafs	Silty Gravel with Sa
141	01058	USDH Beaver Co.	Wah Wah Valley	Aols	Silty Gravel with Sa
142	01057	USDH Beaver Co.	Wah Wah Valley	Aafs	Silty Sand with Gra
143	01056	USDH Beaver Co.	Wah Wah Valley	Aafs	Silty Sand with Gra
144	01055	USDH Beaver Co.	Escalante Desert	Aafs	Silty Sand with Gra

CS BOL	SIEVE ANALYSIS: BEFORE CRUSHING, PERCENT >3"	>1"	PERCENT PASSING AFTER CRUSHING TO 1" MAXIMUM SIZE: 1"	½"	NO. 4	NO. 10	NO. 40	NO. 200	ABRASION TEST (ASTM C 131) PERCENT WEAR	SOUNDNESS TEST (ASTM C 88) PERCENT LOSS: CA	FA	PLASTICITY INDEX (ASTM D 423 and D 424)
	5.3	18.3	100		54.0	31.3	11.0	4.7	27.1			NP
-SM	11.6	18.4	100		60.0	45.8	26.1	8.8	23.4			NP
	0	11.9	100		60.9	50.0	23.1	4.9	32.8			NP
		10.6	100		55.3	38.9	5.7	0.5	26.1			NP
	1.9	25.7	100		58.9	45.2	13.1	3.6	23.8			NP
-SM	4.0	16.5	100		50.5	36.8	21.4	8.1	28.3			NP
-GM	6.2	15.0	100		38.8	25.4	13.2	5.7	27.9			NP
-SM	9.0	20.3	100		54.0	40.2	20.9	7.6	28.8			NP
-GM	5.0	15.0	100		50.8	37.3	18.4	5.8	24.6			NP
	2.5	8.5	100		40.2	27.2	11.7	3.7	28.3			NP
-SM		7.8	100	78.1	54.5	44.5	21.9	9.7	24.2	4.43	10.9	NP
-GM	3.8	19.2	100		48.4	37.8	22.8	9.2	22.6			NP
-GM	2.2	14.0	100	69.9	49.8	31.0	25.0	7.8	24.8			NP
-SM	5.3	13.5	100		73.0	58.5	30.9	11.4	26.0			NP
-SM	7.0	15.9	100		61.8	44.0	18.9	8.4	25.8			NP
-SM	7.5	17.5	100		62.0	45.2	24.1	9.9	24.6			NP

EXISTING TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE A-2
PAGE 1 OF 2

FUGRO NATIONAL, INC.

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MAP NUMBER	SITE NUMBER	DATA SOURCE	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION
145	01054	USDH Beaver Co.	Escalante Desert	Aal	Gravelly Sand
146	01053	USDH Beaver Co.	Escalante Desert	Au	Silty Gravel with San
147	01052	USDH Beaver Co.	Escalante Desert	Au	Sandy Gravel
148	01051	USDH Beaver Co.	Escalante Desert	Au	Gravelly Sand
149	01049	USDH Beaver Co.	Escalante Desert	Au	Gravelly Sand
150	11074	USDH Iron Co.	Escalante Desert	Au	Gravelly Sand

SIEVE ANALYSIS								ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		PLASTICITY INDEX (ASTM D 423 and D 424)
BEFORE CRUSHING, PERCENT		PERCENT PASSING AFTER CRUSHING TO 1" MAXIMUM SIZE						PERCENT WEAR	PERCENT LOSS		
>3"	>1"	1"	½"	NO. 4	NO. 10	NO. 40	NO. 200		CA	FA	
4.8	8.3	100		63.9	41.1	13.3	4.1	24.0			NP
	28.6	100		51.0	34.4	13.2	6.1	21.6			NP
	37.4	100		47.0	33.3	13.8	4.6	21.3			NP
	12.5	100	84.9	60.1	39.5	11.4	3.7	20.6			NP
0	4.6	100	90.9	73.5	*57.9	*3.6	1.3	31.0	35.2	10.4	NP
	6.1	100	9.3	75.2	54.2	13.9	3.8	27.1			NP

EXISTING TEST DATA
PINE AND WAH WAH VALLEYS, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE A-2
PAGE 2 OF 2

FUGRO NATIONAL, INC.

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APPENDIX B

SUMMARY OF CALICHE DEVELOPMENT

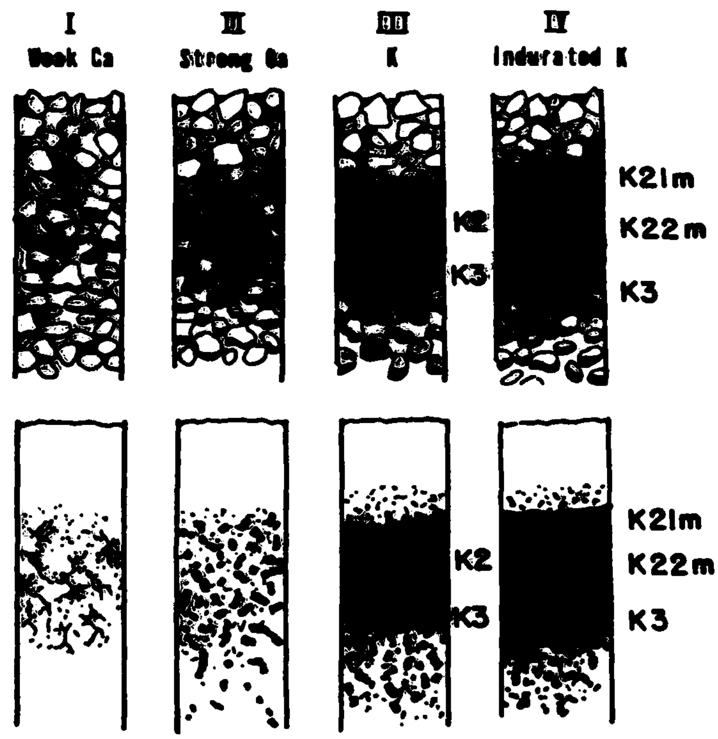
DIAGNOSTIC CARBONATE MORPHOLOGY

STAGE	GRAVELLY SOILS	NONGRAVELLY SOILS
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Laminar horizon overlying plugged horizon

STAGE

GRAVELLY SOILS

NONGRAVELLY SOILS



Stages of development of a caliche profile with time. Stage I represents incipient carbonate accumulation, followed by continuous build-up of carbonate until, in Stage IV, the soil is completely plugged.

Reference: Gile,L.H. Peterson,F.F., and Grossman,R.B.,1965, The K horizon: A master horizon of carbonate accumulation: Soil Science, v. 99, p. 74-82.

SUMMARY OF CALICHE DEVELOPMENT	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	APPENDIX B
FUGRO NATIONAL, INC.	

APPENDIX C

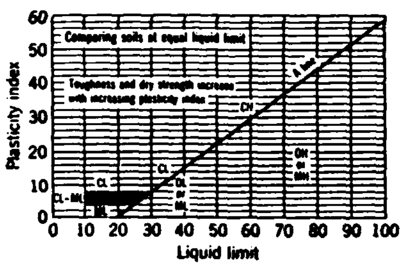
UNIFIED SOIL CLASSIFICATION SYSTEM

Major divisions			Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils. *More than half of material is larger than No. 200 sieve size*[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels. More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4 / Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Atterberg limits above "A" line, with *PI* greater than 7
	Sands. More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 / Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Laboratory classification criteria for coarse-grained soils: Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols.

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major divisions		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Fine-grained soils. *More than half of material is smaller than No. 200 sieve size* (The No. 200 sieve size is about the smallest particle visible to naked eye)	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

From Wagner, 1957.

[a] *Boundary classifications.* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking):

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):

After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

UNIFIED SOIL CLASSIFICATION SYSTEM

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

APPENDIX C

FUGRO NATIONAL, INC.

APPENDIX D

PINE AND WAH WAH VALLEYS
STUDY AREA PHOTOGRAPHS

Alluvial Fan Deposit (Aafs) in east central Pine Valley; Class I coarse and fine (multiple) aggregate source (Station 27).

PINE AND WAH WAH VALLEYS
STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE – BMO	FIGURE D-1

FUGRO NATIONAL, INC.

Older Lacustrine Shoreline Deposit (Aolg) along eastern Wah Wah Valley; Class I coarse and fine (multiple) aggregate source (Station 38).

PINE AND WAH WAH VALLEYS
STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO

FIGURE D-2

FUGRO NATIONAL, INC.

Older Lacustrine Deposit (Aols) in northern Wah Wah Valley; Class I coarse and fine (multiple) aggregate source (Station 35).

PINE AND WAH WAH VALLEYS
STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO

FIGURE D-3

FUGRO NATIONAL, INC.

Prospect Mountain Quartzite (Qtz) in Wah Wah Mountains;
Class I crushed rock aggregate source (Station 26).

PINE AND WAH WAH VALLEYS
STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE — BMO	FIGURE D-4

FUGRO NATIONAL, INC.

Basalt (Vb) in northern Wah Wah Valley; Class I crushed rock aggregate source (Station 55).

PINE AND WAH WAH VALLEYS STUDY AREA PHOTOGRAPH	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE — BMO	FIGURE D-5
FUGRO NATIONAL, INC.	

APPENDIX E

FUGRO NATIONAL GEOLOGIC UNIT CROSS REFERENCE

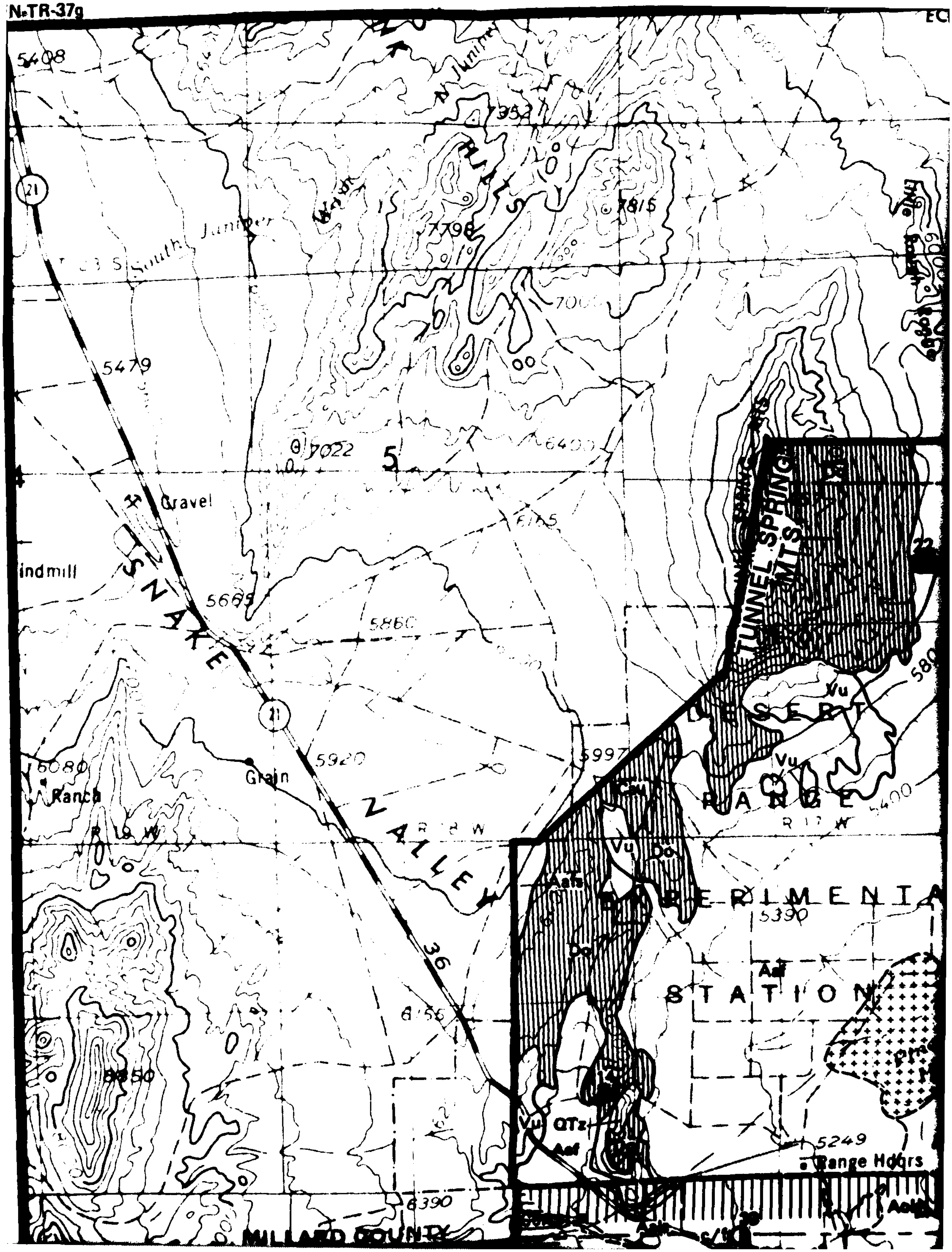
U ARSA POTENTIAL AGGREGATE SOURCE SYMBOLS	FUGRO NATIONAL GENERAL GEOLOGIC UNIT EXPLANATION
	[illegible]
GR	[illegible]
Vu	[illegible]
Vb	[illegible]
Vu	[illegible]
Su	[illegible]
Su, Qtz	[illegible]
Ls, Do, Cau	[illegible]
	[illegible]
	[illegible]
Su	[illegible]
Mu	[illegible]
Mu	[illegible]
Mu	[illegible]
Mu	[illegible]
Qtz	[illegible]
	[illegible]
Aal	[illegible]
Au, Aal	[illegible]
Au	[illegible]
Aal	[illegible]
Aaf	[illegible]
Au	[illegible]
Aaf	[illegible]

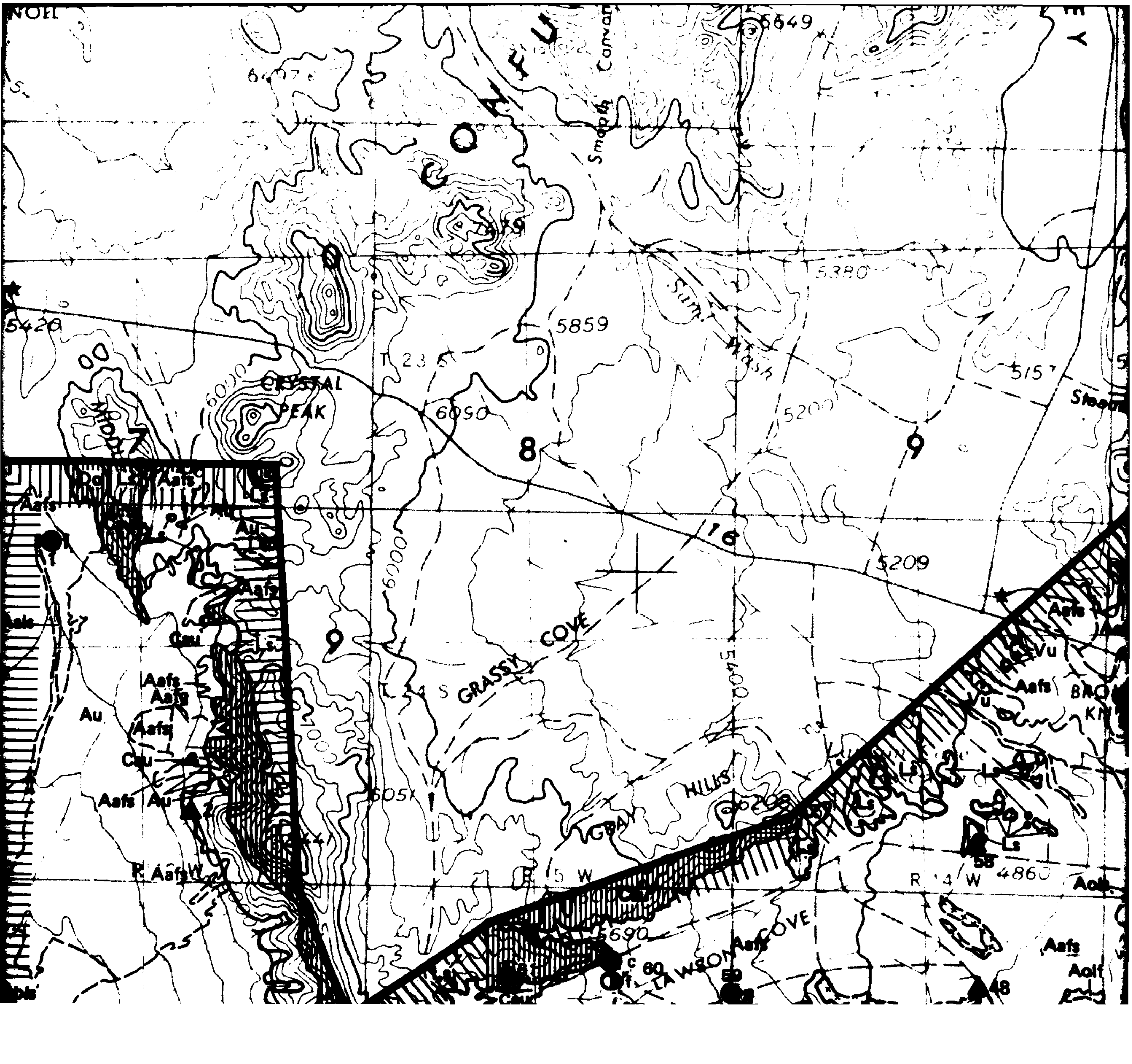
FUGRO NATIONAL GEOLOGIC UNIT CROSS REFERENCE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - [illegible]

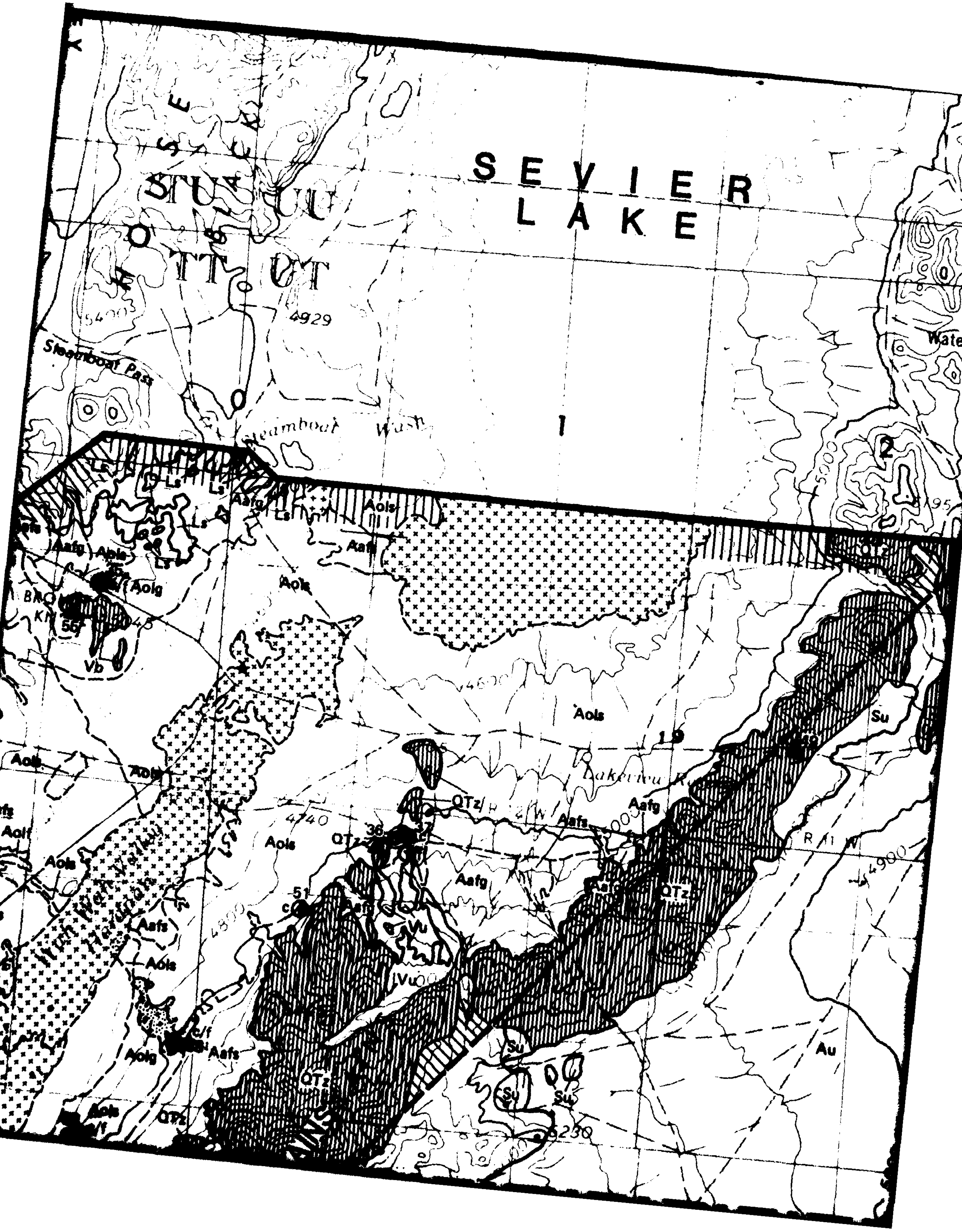
APPENDIX E

FUGRO NATIONAL, INC.

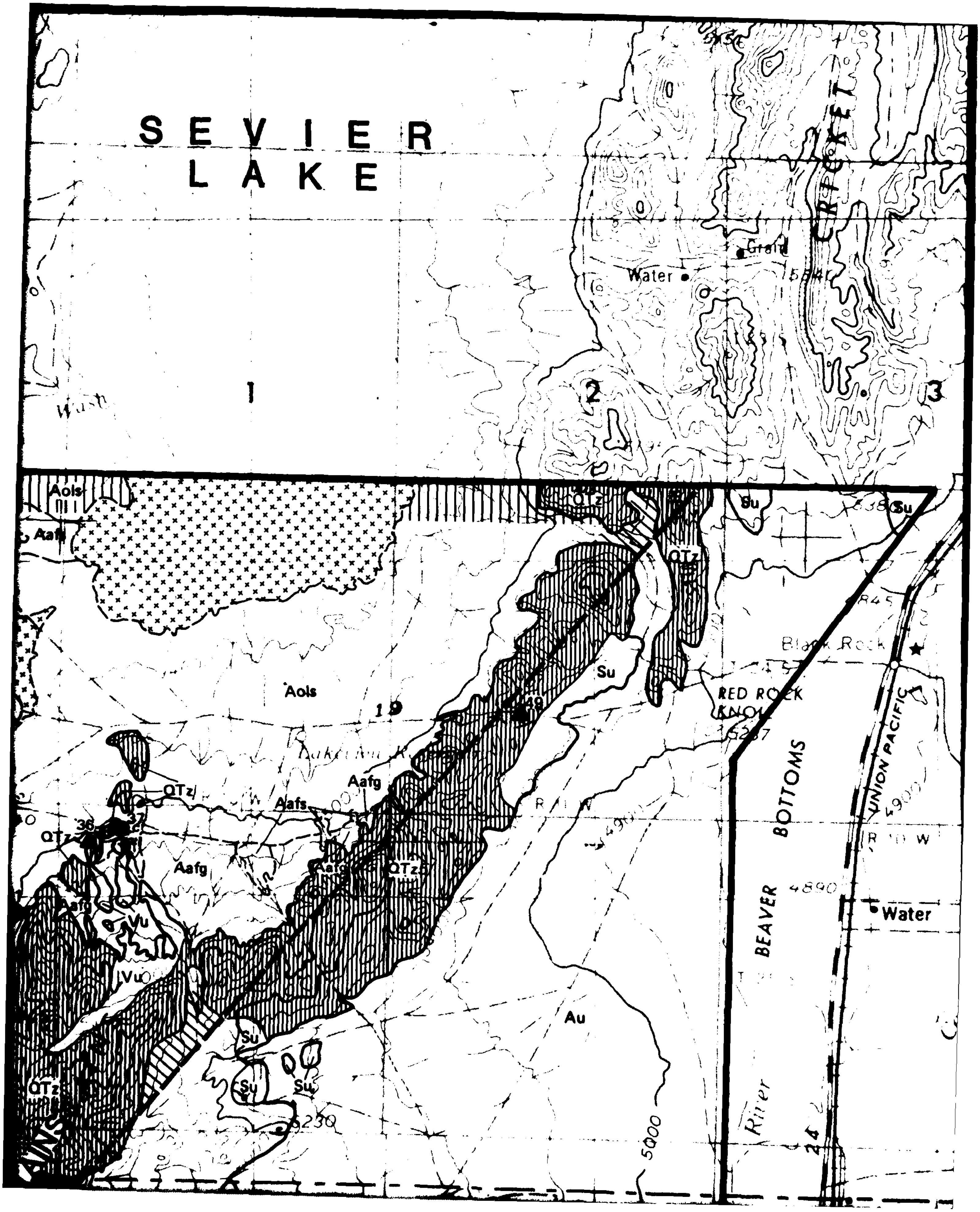

5408
HILLS
7352
7815
7798
South Juniper
5479
7022
5
Gravel
Windmill
SNAKE VALLEY
5665
5860
TUNNEL SPRINGS MTS
DESERT
RANGE
EXPERIMENTAL
STATION
5997
5920
Grain
6080
Ranch
R 19 W
R 18 W
R 17 W
Vu
Do
Aafs
Aaf
QTz
5390
5249
Range Hdqrs
6390
MILLARD COUNTY
21
36



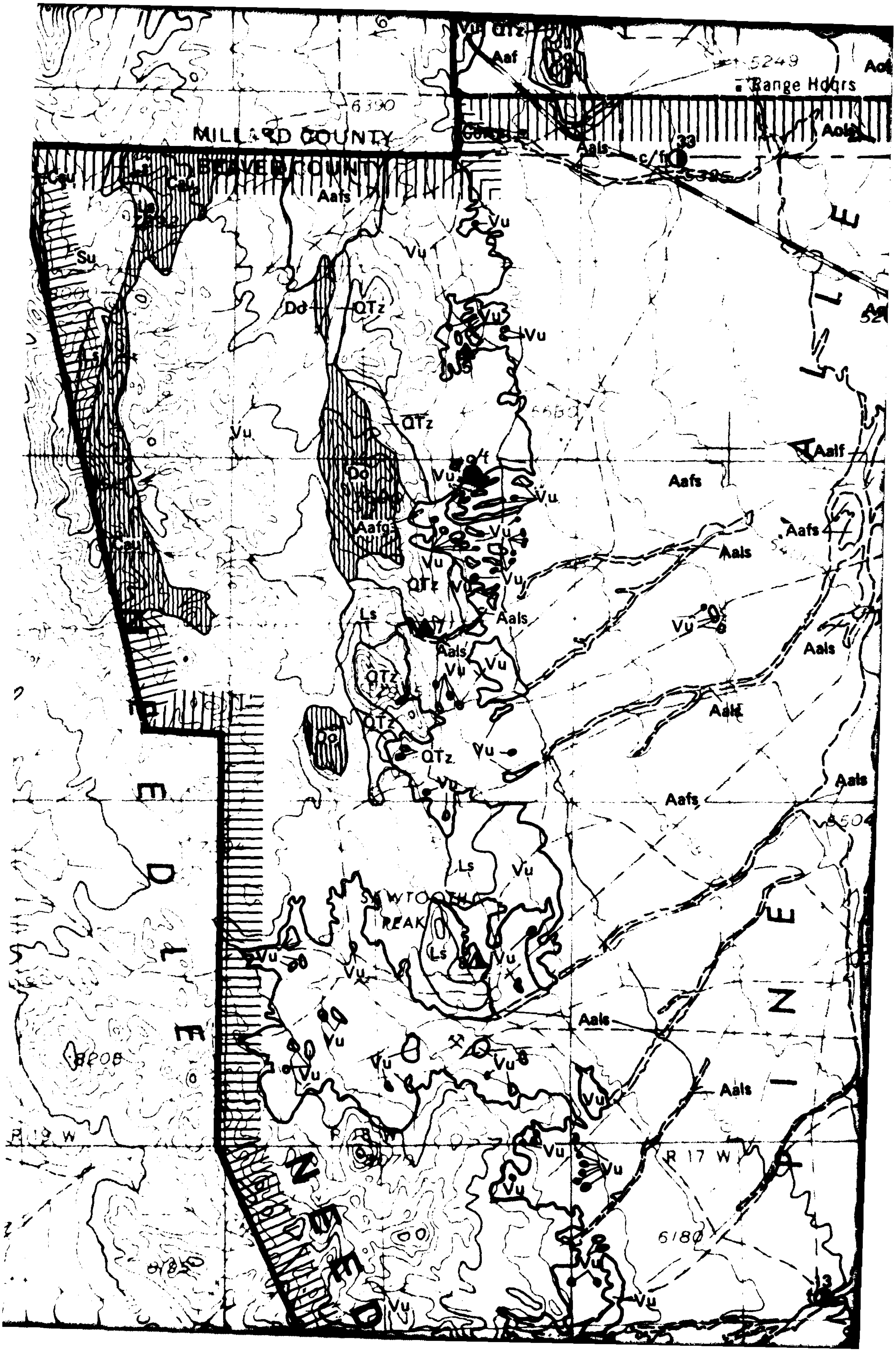
CONFU
5649
5859
CRYSTAL PEAK
6050
8
9
5380
5200
5157
16
5209
GRASSY COVE
HILLS
6000
Aafs
Au
Cau
Ls
R 15 W
R 14 W
4860
5690
LAWSON
COVE



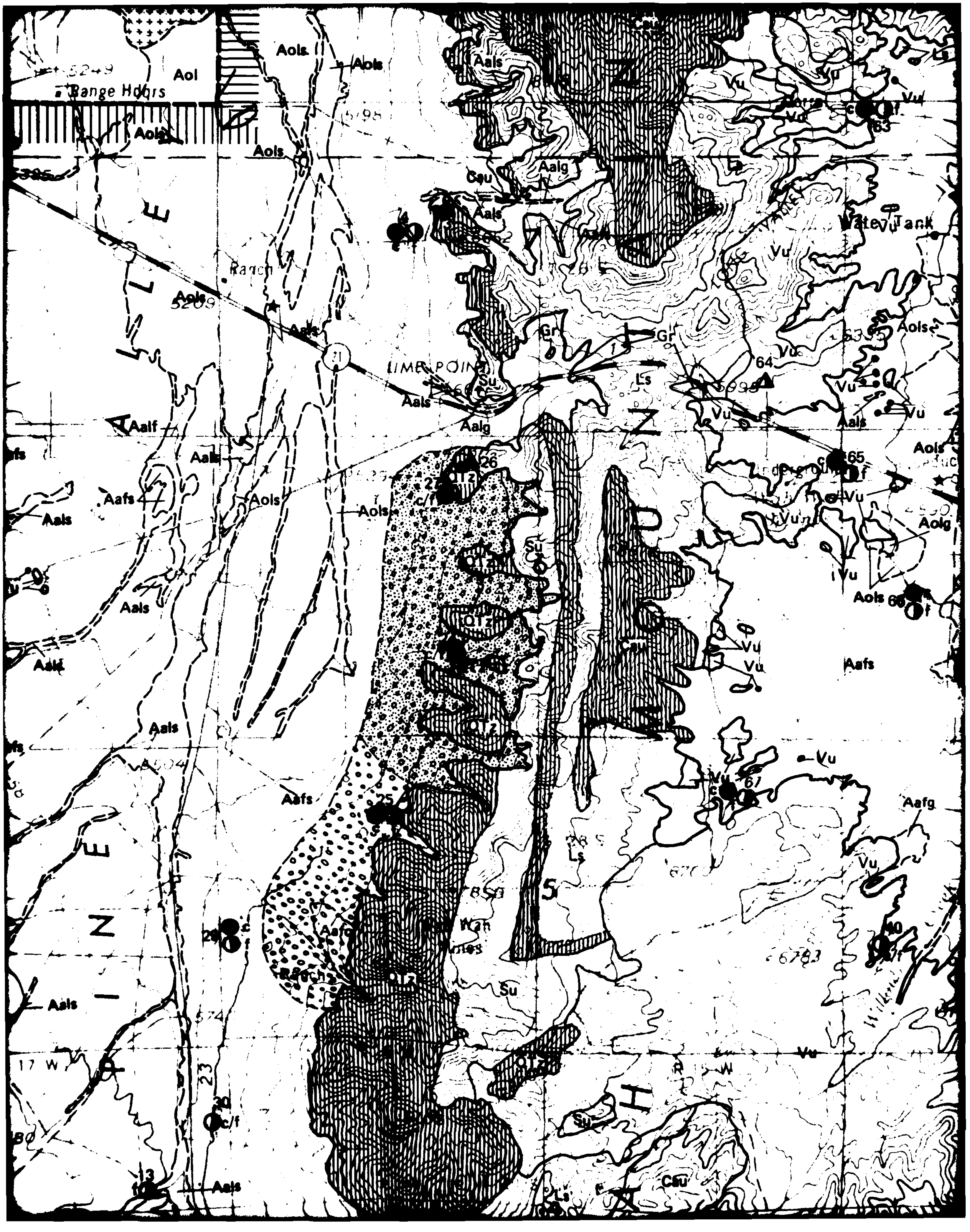
SEVIER
LAKE
Steamboat Pass
Steamboat Wash
4929
Aols
Aafs
Aafg
Aolg
QTz
Ls
Vb
Vu
Su
Au
R 14 W
R 13 W
4740
4900
19
1
2

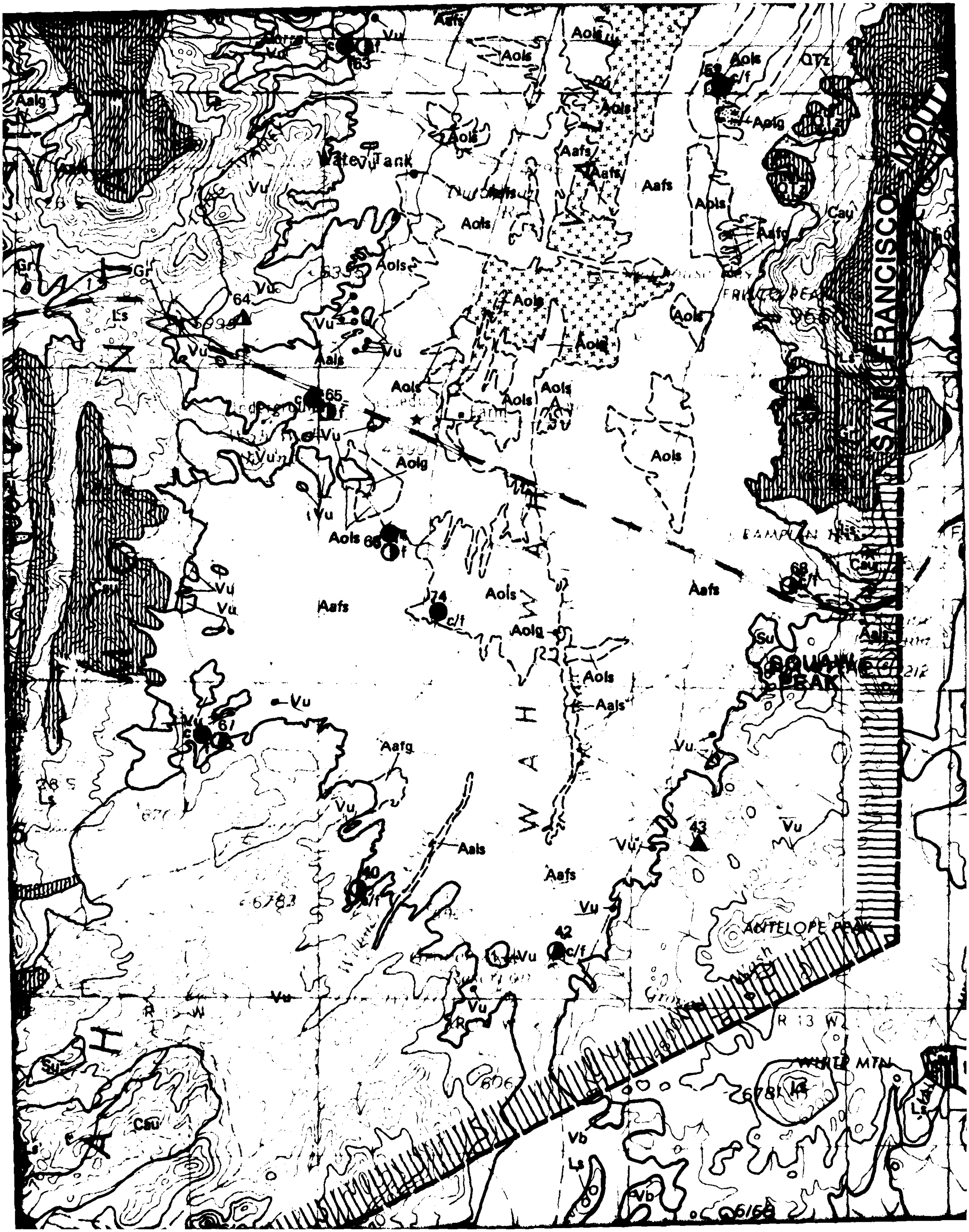


SEVIER
LAKE
CRICKET
Water
Grass
1
2
3
Wash
Aols
Aafs
Aafg
QTz
Su
Vu
Au
19
36
37
49
Black Rock
RED ROCK KNOLL
5287
BEAVER BOTTOMS
UNION PACIFIC
Water
4890
4900
5000
5230
River
24
R 10 W

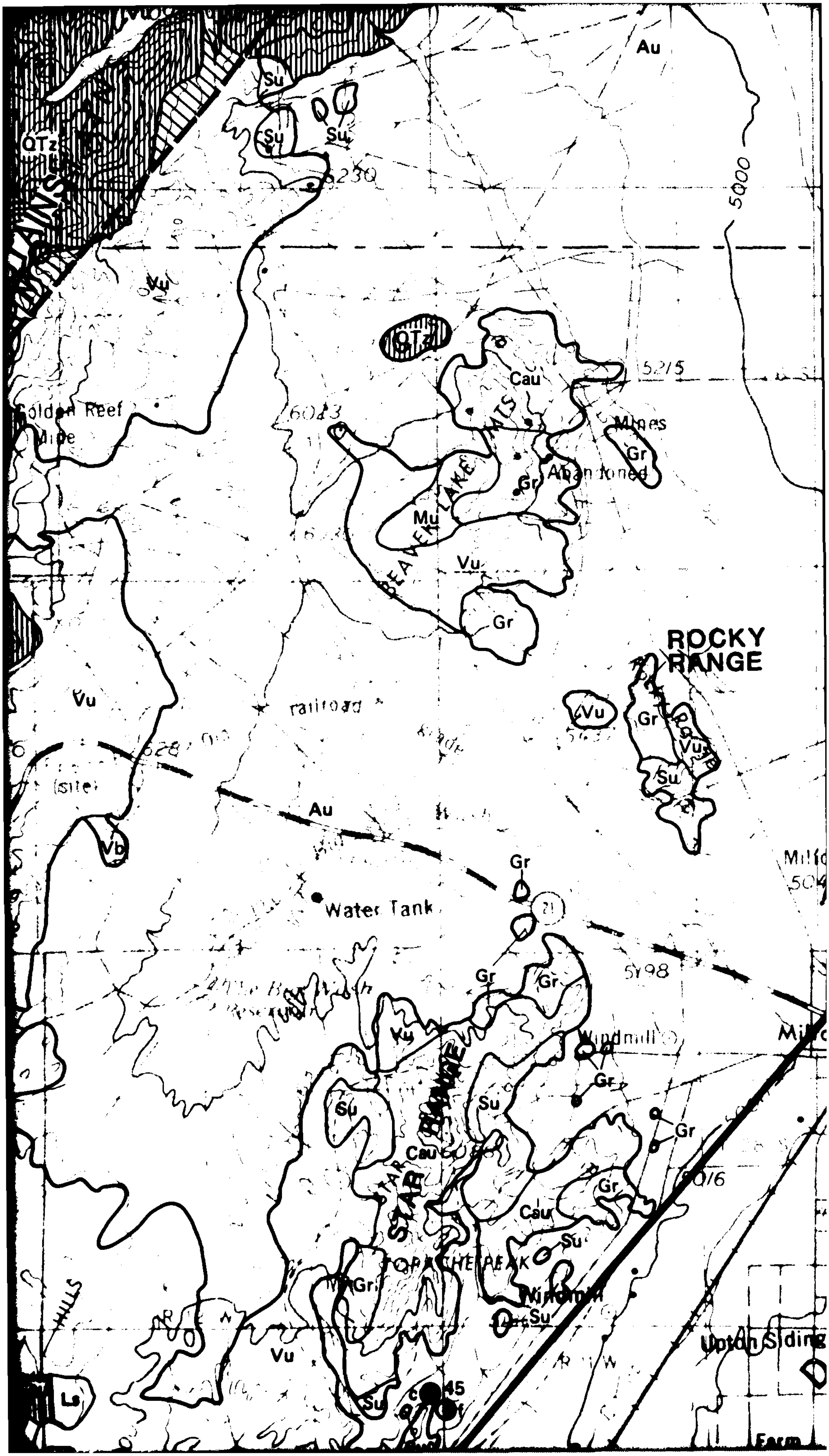


MILLARD COUNTY
BEAVER COUNTY
Range Hdqrs
5249
6390
6395
6504
6180
8208
SAWTOOTH PEAK
R 17 W
Aafs
Aals
Aafg
Aalf
QTz
Vu
Dd
Ls
Su
Cau

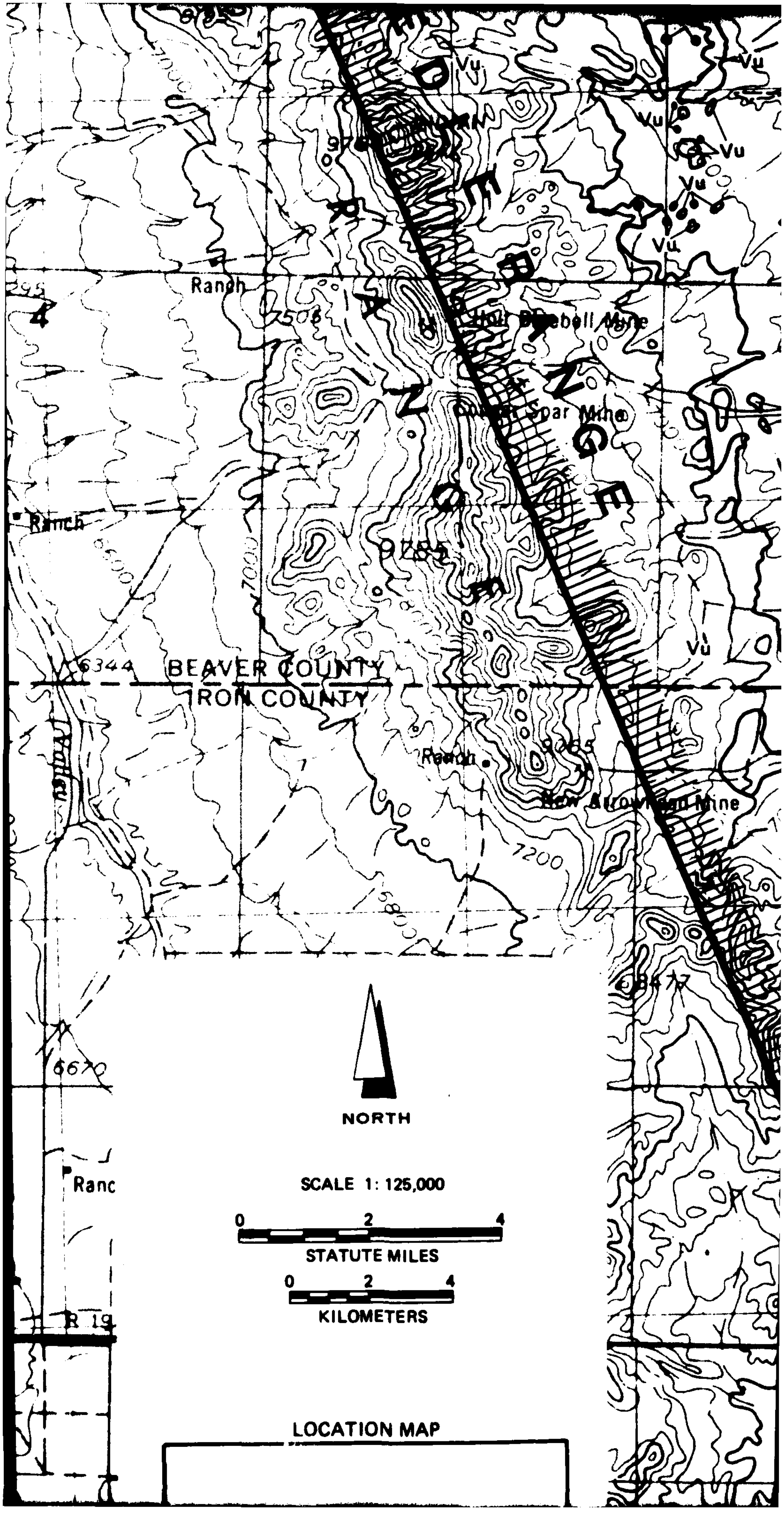

Range Hdqrs
Aol
Aols
Aals
Aalg
Aalf
Aafs
Aafg
Aolg
Cau
Gr
Ls
Su
Vu
Qtz
c/f
Water Tank
Ranch
5209
LIME POINT
17 W



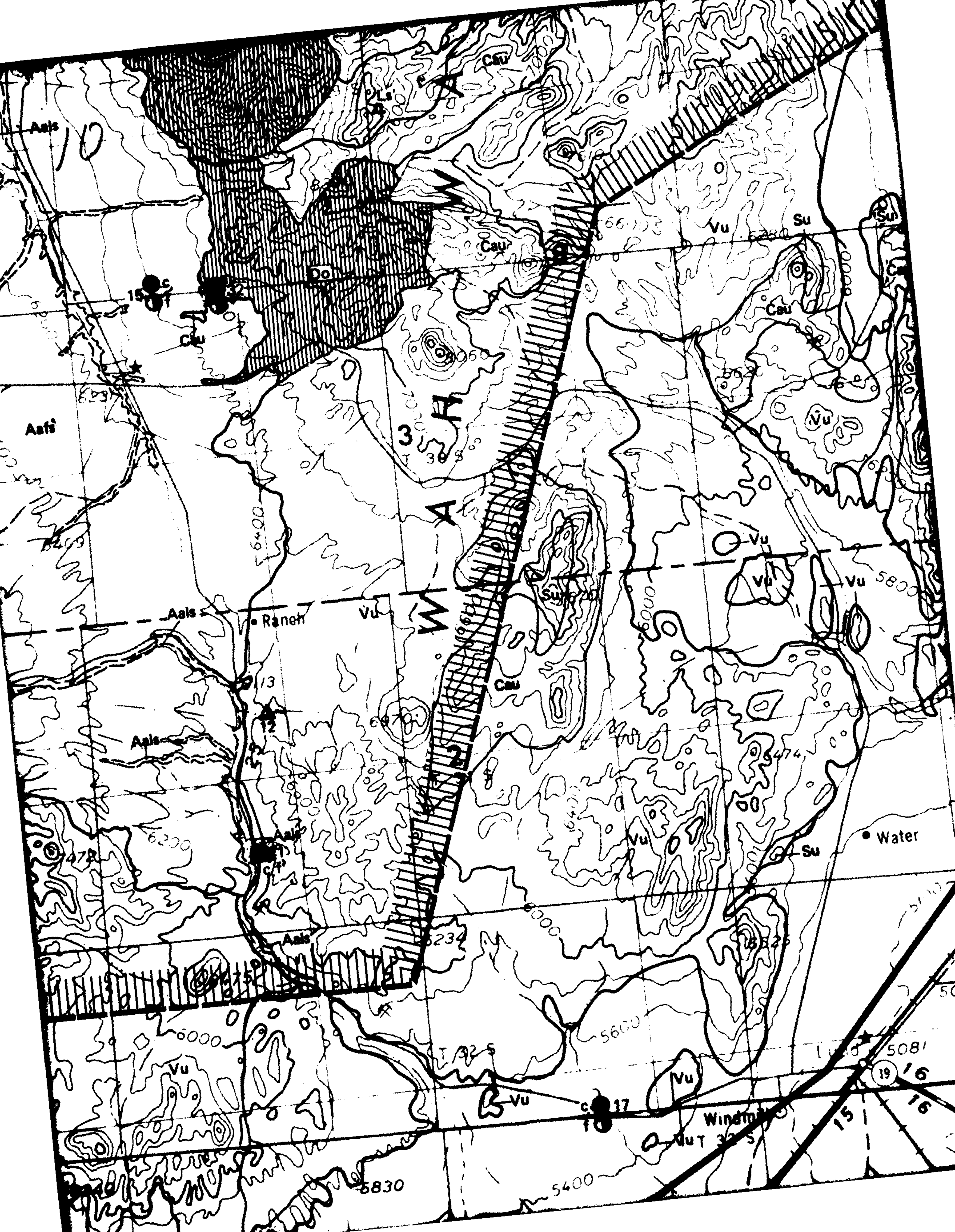
Water Tank
Aols
Aafs
Aolg
Aals
Aafg
Vu
Cau
Ls
Gr
QTz
Su
Vb
SAN FRANCISCO
SQUAW PEAK
ANTELOPE PEAK
WHITE MTN
W A H
R 13 W
63
64
65
66
67
68
74
40
42
43
c/f

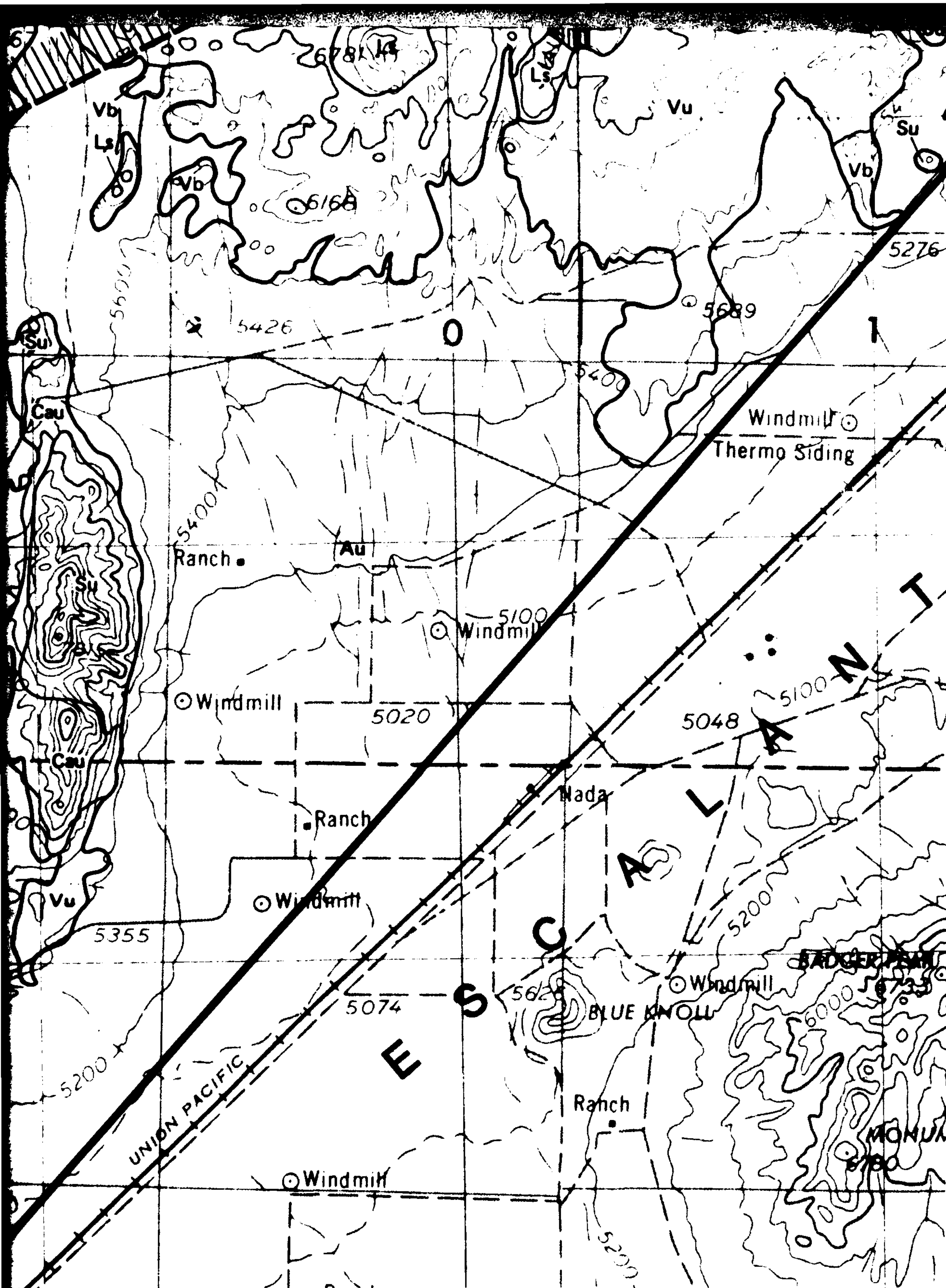


Au
Su
QTz
5230
5000
Vu
QTzl
Cau
5275
Golden Reef
Mine
6043
MTS
Mines
Gr
Abandoned
BEAVER LAKE
Mu
ROCKY
RANGE
railroad
grade
Vb
Water Tank
5198
Windmill
STAR RANGE
TOP OF THE PEAK
Windmill
Upton Siding
Ls
45



Vu
Ranch
Copper Spar Mine
New Arrowhead Mine
BEAVER COUNTY
IRON COUNTY
6344
7000
7200
6670
Ranc
R 19
NORTH
SCALE 1: 125,000
0 2 4
STATUTE MILES
0 2 4
KILOMETERS
LOCATION MAP


10
Aals
Aafs
Cau
Do
Ls
Vu
Su
Sub
Ranch
Water
Windmill
6400
6200
6000
5800
5600
5400
5830
5081
6234
6470
5474
T 32 S
T 33 S
12
13
15
16
17
19
2
3



CLASSIFICATION SYSTEM

BASIN-FILL SOURCES

Class I - Potentially Suitable Coarse, Concrete Aggregate or Road - Base Material Source

Aal Str

Aaf All

Aol Old

Au All

Vb Bas

Vu Vol

Gr Gra

Mu Met

Qtz Qu

Ls Lim

Do Dol

Cau Car

Su Sed

*Reference A

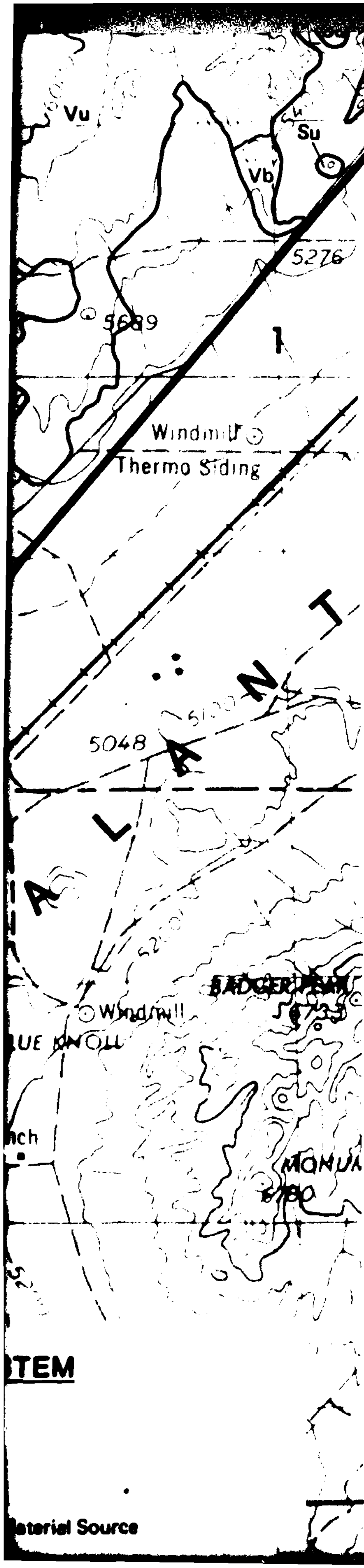
Aafg Ma Gr san

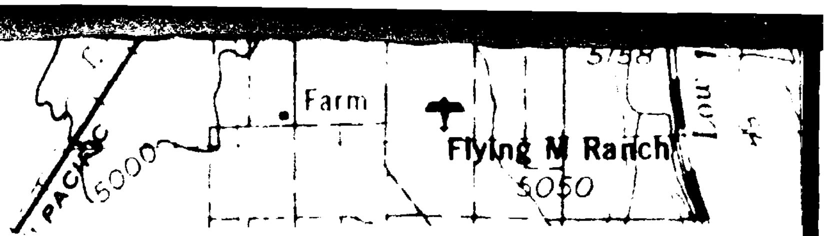
Geo

App Roa

Ver

FUGRO NA
SAMPLE





EXPLANATION

POTENTIAL AGGREGATE SOURCES

BASIN-FILL UNITS*

Aal	Stream Channel and Terrace Deposits	(A1)
Aaf	Alluvial Fan Deposits	(A5)
Aol	Older Lacustrine Deposits	(A4o)
Au	Alluvial Deposits Undifferentiated	

ROCK UNITS*

Vb	Basalt	(I3)
Vu	Volcanic Rocks Undifferentiated	(I2 and/or I4)
Gr	Granitic Rock	(I1)
Mu	Metamorphic Rocks Undifferentiated	(M)
Qtz	Quartzite	(M4 and/or S1)
Ls	Limestone	(S2)
Do	Dolomite	(S2)
Cau	Carbonate Rocks Undifferentiated	(S2)
Su	Sedimentary Rocks Undifferentiated	(S)

*Reference Appendix E for Symbol Explanation and Comparison

SYMBOLS

Aafg — Material type (Aaf) and Grain Size Designation (g). Grain size designations are cobble (c), gravel (g) and sand (s).

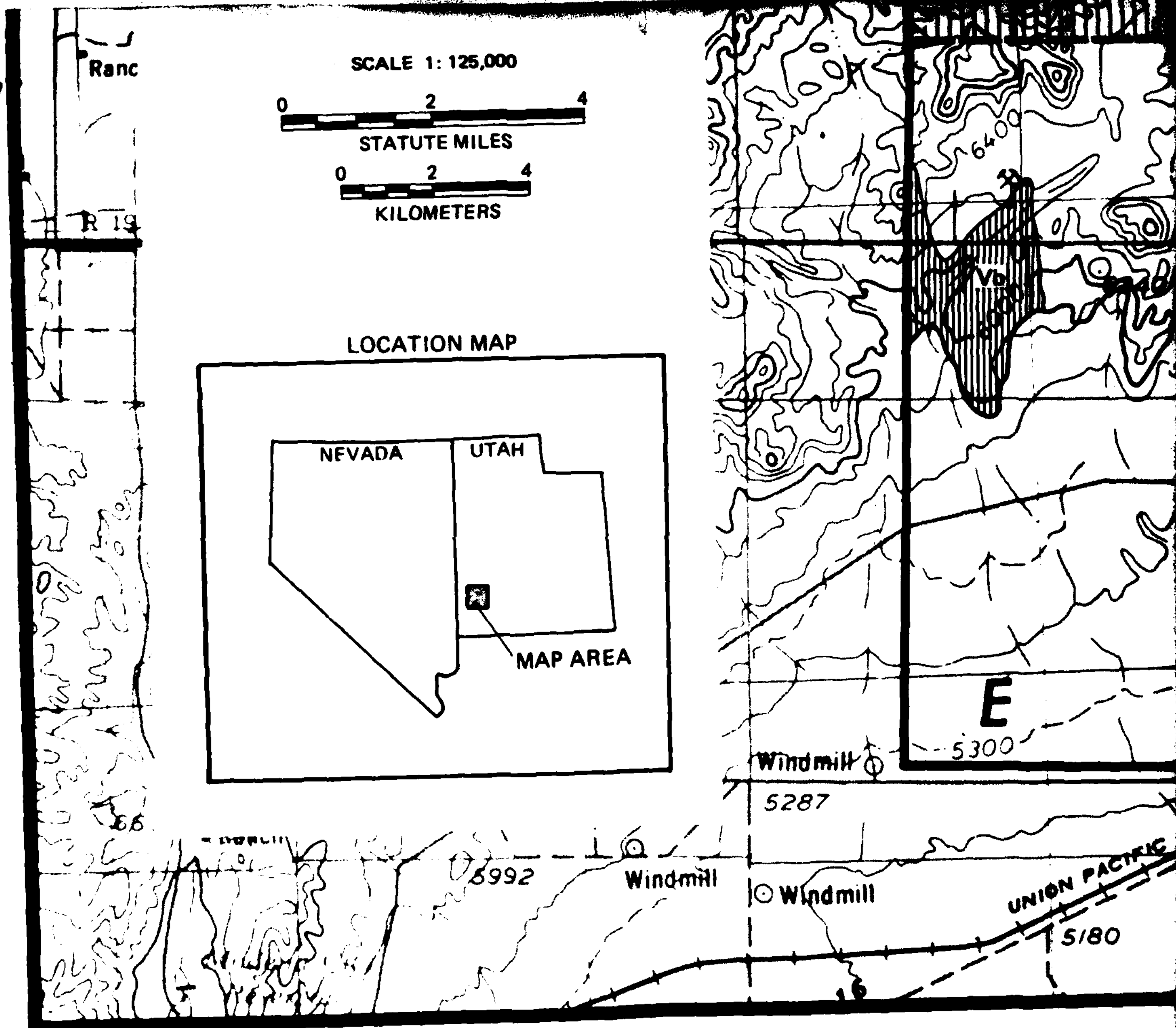
– – – – Geologic Contact, Dashed Where Approximate

– – – – Approximate-Concrete Aggregate and/or Road-Base Materials Source Boundary

Verification Study Area

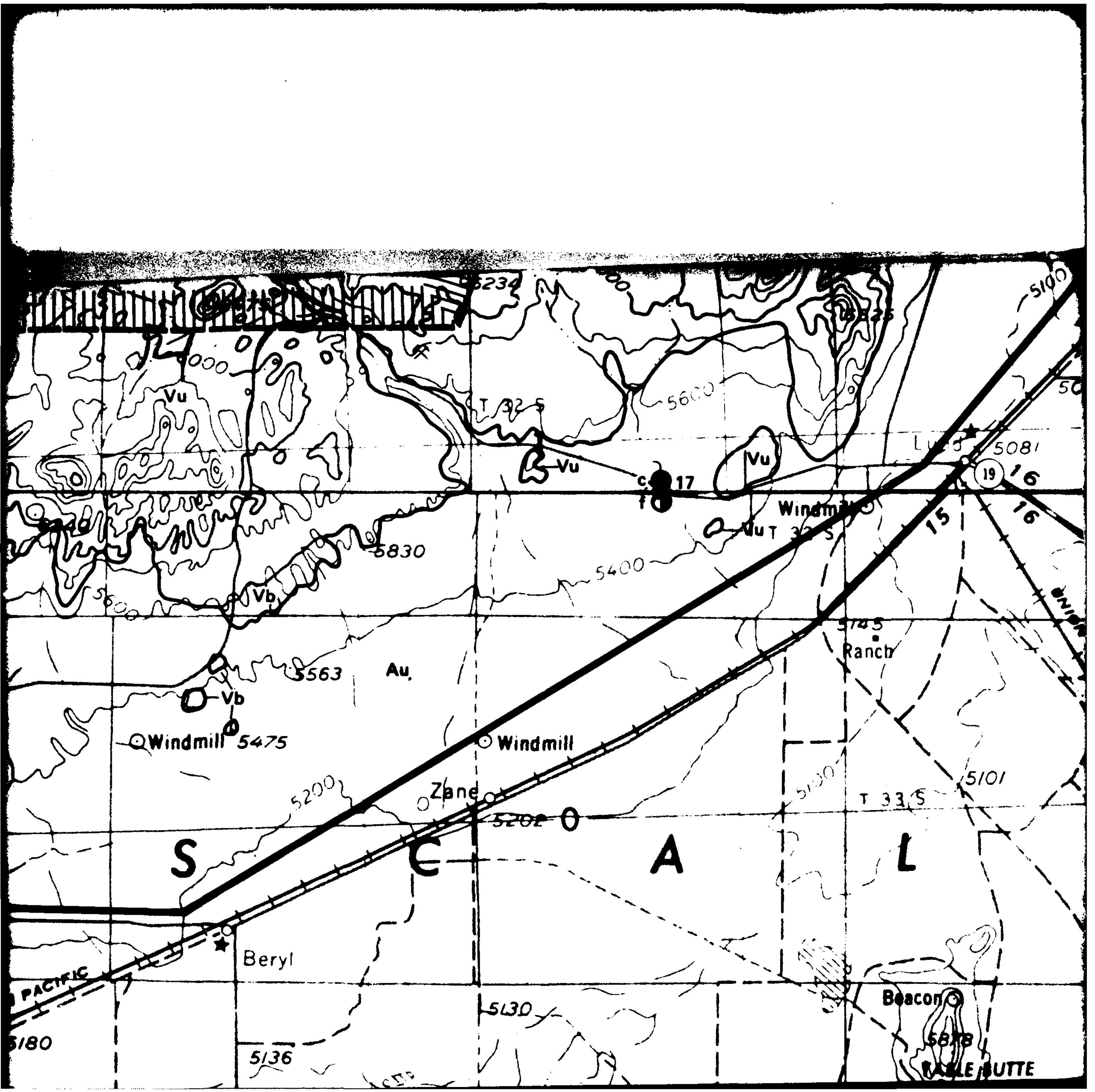
FUGRO NATIONAL AGGREGATE RESOURCES
SAMPLED AND TESTED FIELD STATIONS

13

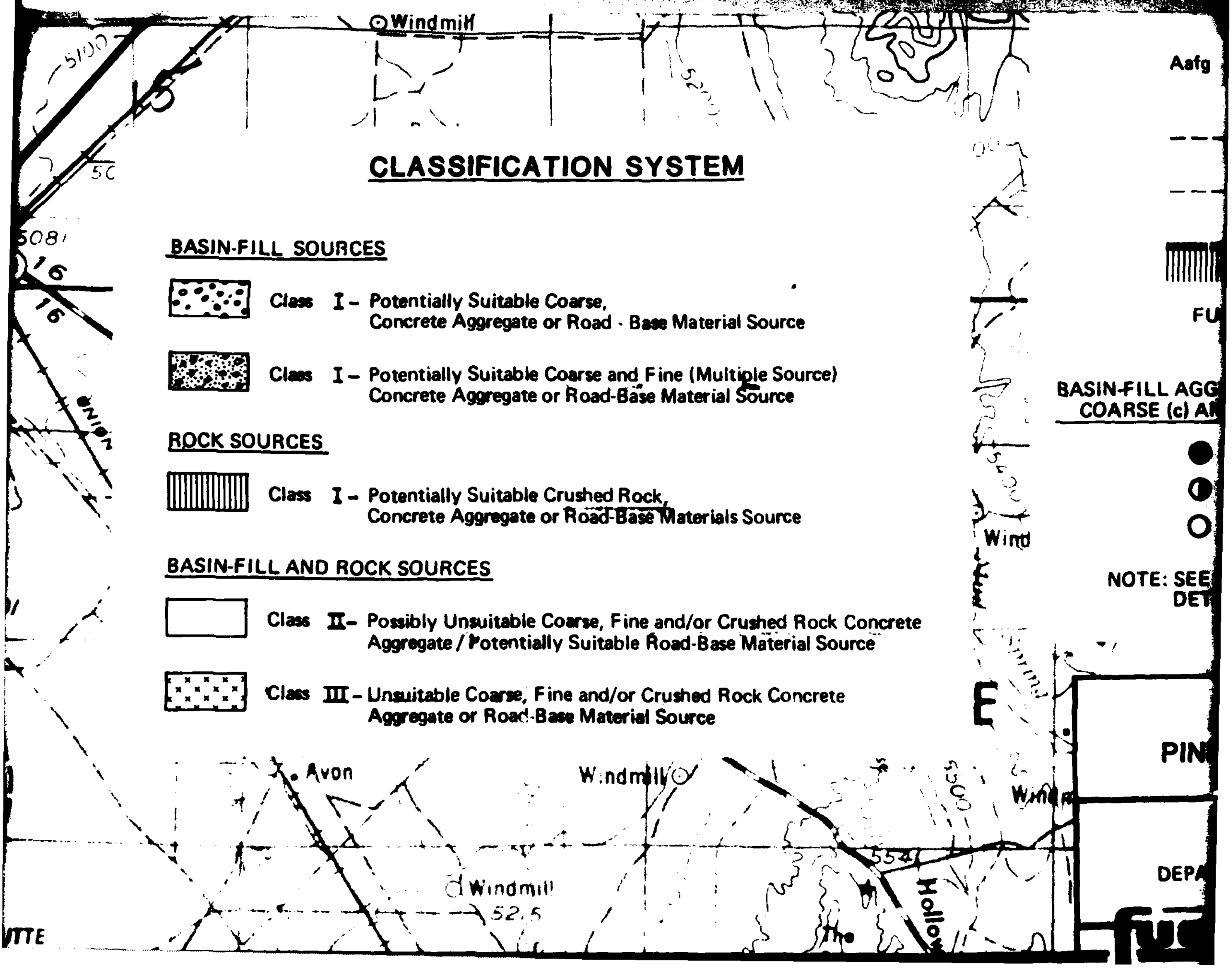


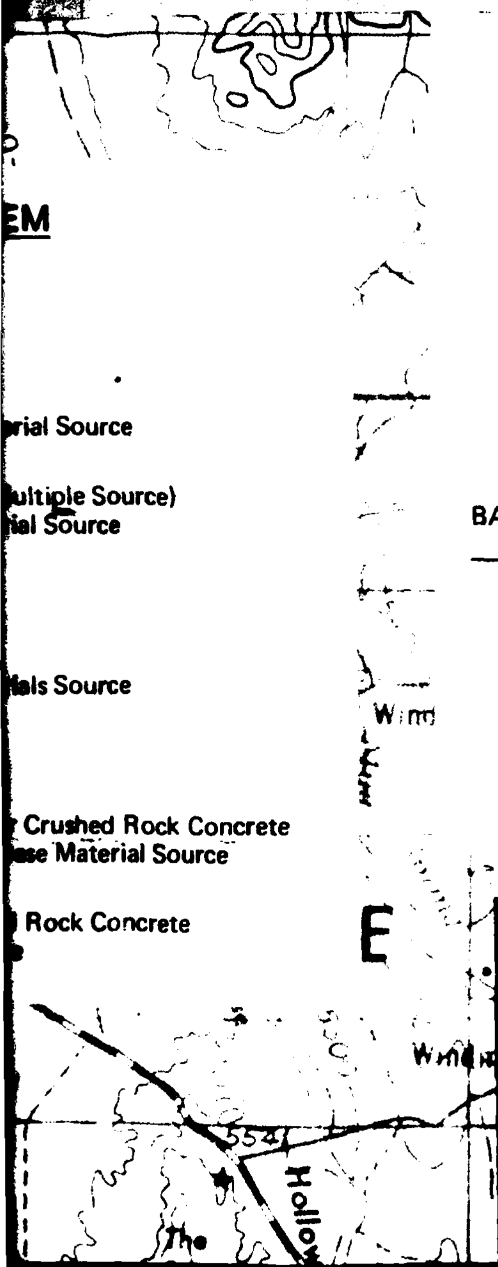
Ranc
SCALE 1: 125,000
0 2 4
STATUTE MILES
0 2 4
KILOMETERS
LOCATION MAP
NEVADA
UTAH
MAP AREA
6400
Vb
E
5300
Windmill
5287
5992
Windmill
Windmill
UNION PACIFIC
5180

27 FEB 81



5234
5100
T 32 S
5600
Vu
Vu
Vu
17
Lund
5081
19
16
16
15
Windmill
5830
5400
Vb
Ranch
5563
Au
Vb
Windmill 5475
Windmill
5200
Zane
5202
5101
T 33 S
S
C
A
L
Beryl
PACIFIC
5180
5130
5136
Beacon
5878
BUTTE


Windmill
Aafg
CLASSIFICATION SYSTEM
BASIN-FILL SOURCES
Class I – Potentially Suitable Coarse, Concrete Aggregate or Road - Base Material Source
Class I – Potentially Suitable Coarse and Fine (Multiple Source) Concrete Aggregate or Road-Base Material Source
ROCK SOURCES
Class I – Potentially Suitable Crushed Rock, Concrete Aggregate or Road-Base Materials Source
BASIN-FILL AND ROCK SOURCES
Class II – Possibly Unsuitable Coarse, Fine and/or Crushed Rock Concrete Aggregate / Potentially Suitable Road-Base Material Source
Class III – Unsuitable Coarse, Fine and/or Crushed Rock Concrete Aggregate or Road-Base Material Source
Avon
Windmill
Windmill
52.5
Hollow
The



Aafg	Material type (Aaf) and Grain Size Designation (g). Grain size designations are cobble (c), gravel (g) and sand (s).
----	Geologic Contact, Dashed Where Approximate
----	Approximate-Concrete Aggregate and/or Road-Base Materials Source Boundary
	Verification Study Area

FUGRO NATIONAL AGGREGATE RESOURCES SAMPLED AND TESTED FIELD STATIONS

BASIN-FILL AGGREGATE SAMPLE COARSE (c) AND FINE (f)	CRUSHED ROCK SAMPLE	CLASSIFICATION
●	▲	CLASS I
◐	▲	CLASS II
○	△	CLASS III

NOTE: SEE CORRESPONDING MAP NUMBER IN APPENDIX A FOR DETAILED INFORMATION

AGGREGATE RESOURCES MAP PINE AND WAH WAH VALLEYS, UTAH

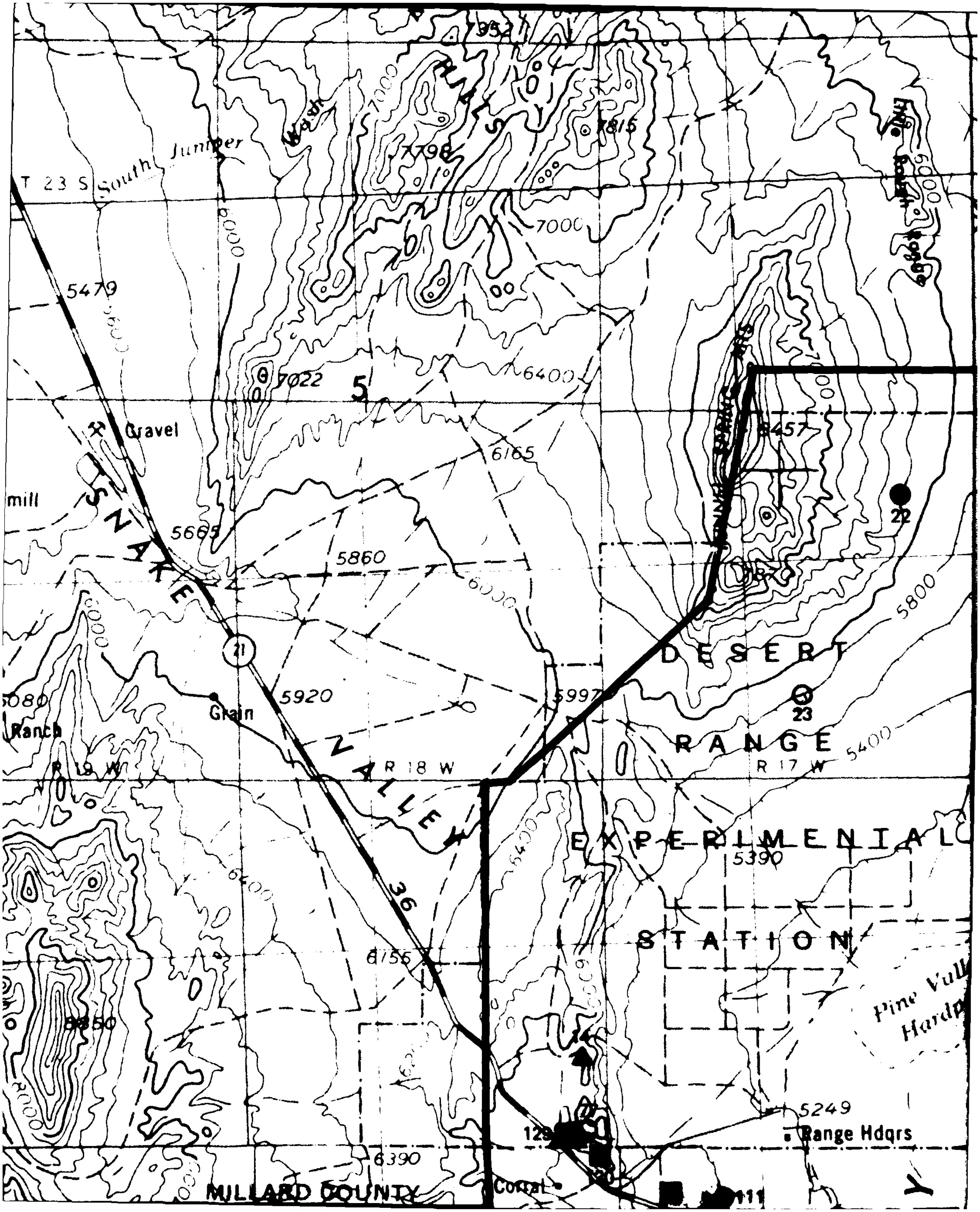
MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE – BMO

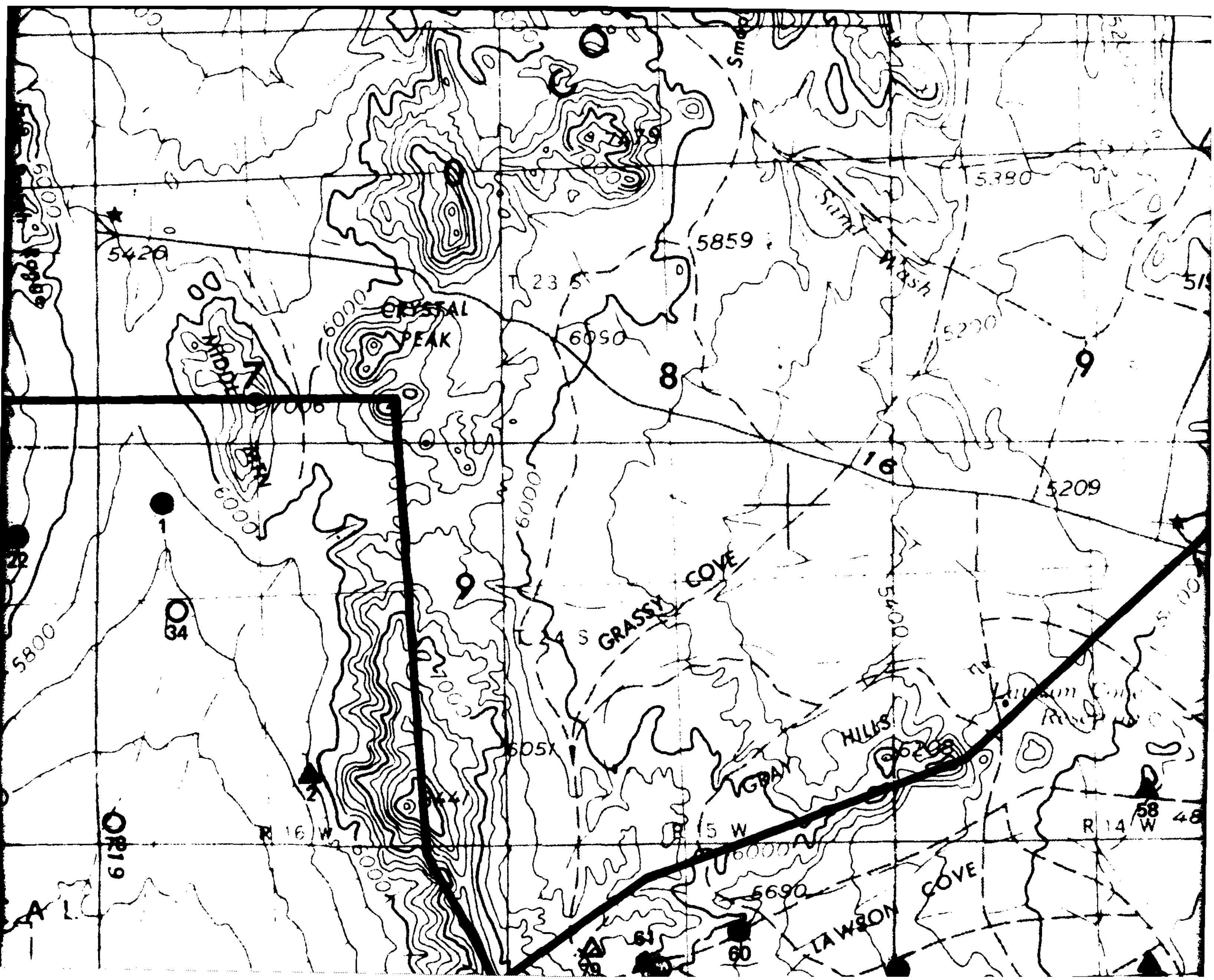
DRAWING 2

FUGRO NATIONAL, INC.

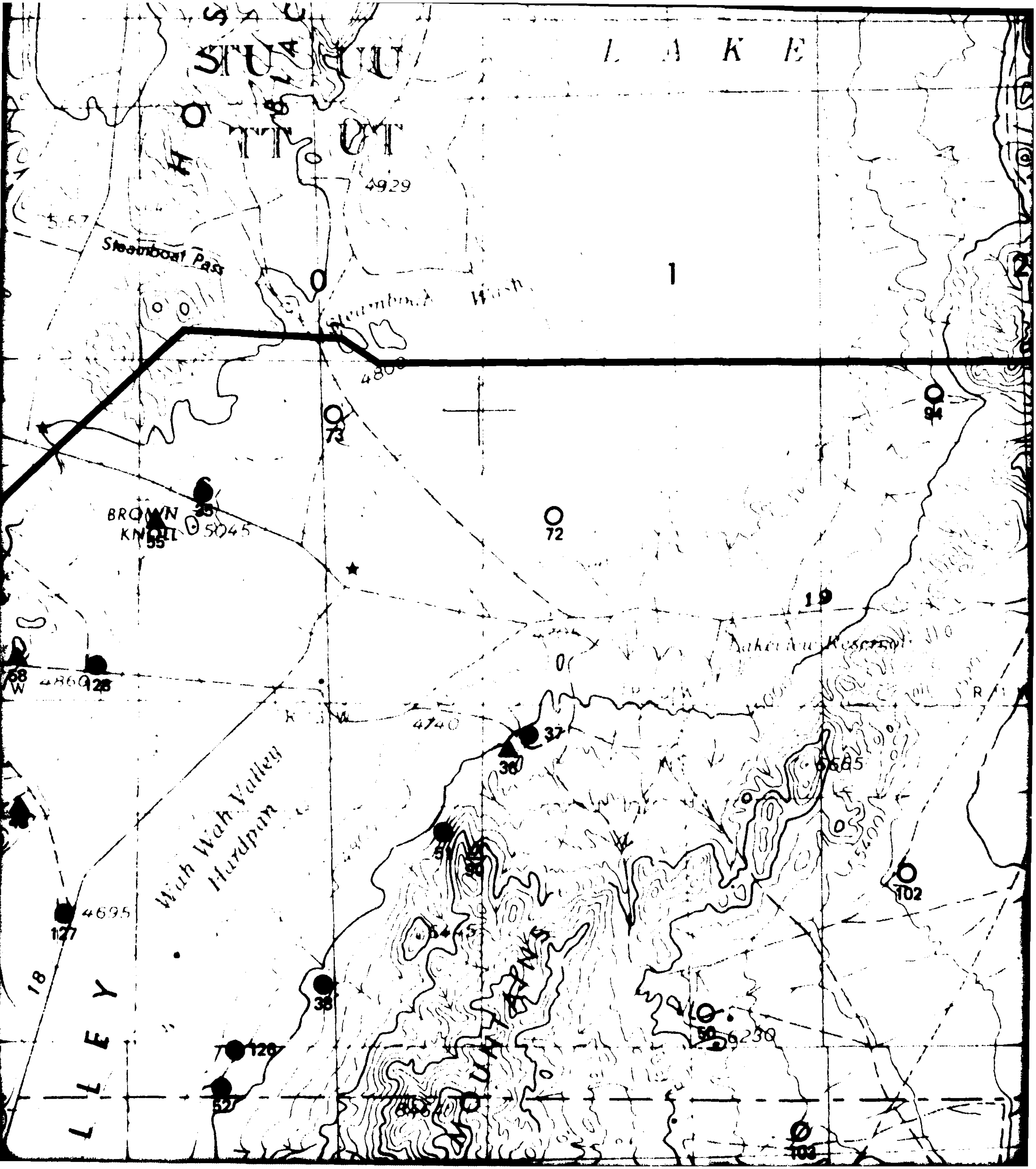
16



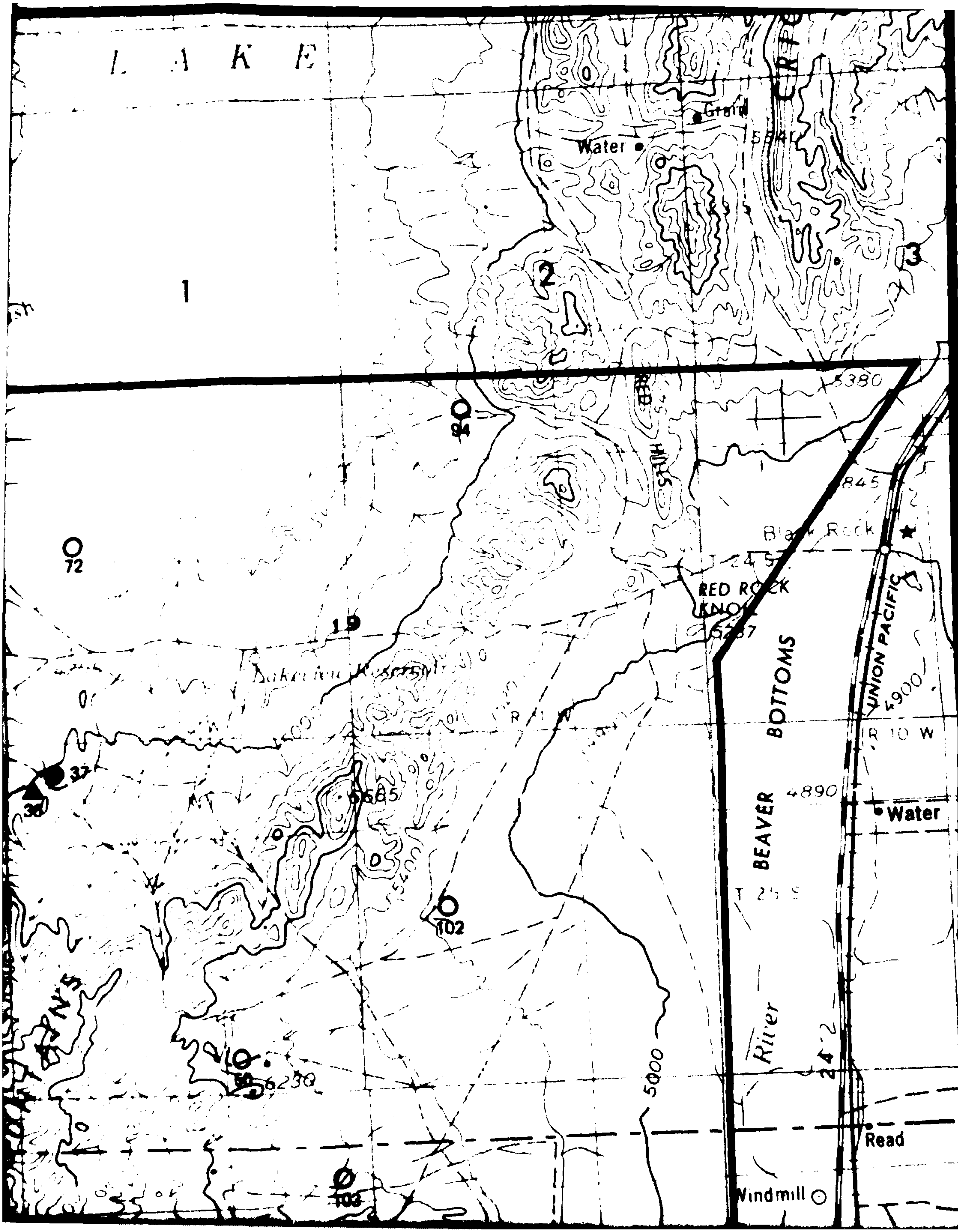
T 23 S
South Juniper Wash
7952
7798
7815
7000
6000
5479
7022
5
6400
Gravel
mill
6165
5665
SNAKE
5860
6000
21
Grain
5920
5997
DESERT
23
22
5800
8457
Ranch
RANGE
R 19 W
R 18 W
R 17 W
5400
VALLEY
EXPERIMENTAL
5390
36
6400
STATION
6155
8850
8000
Pine Valley Hardpan
5249
Range Hdqrs
6390
129
120
111
MILLARD COUNTY
Corral



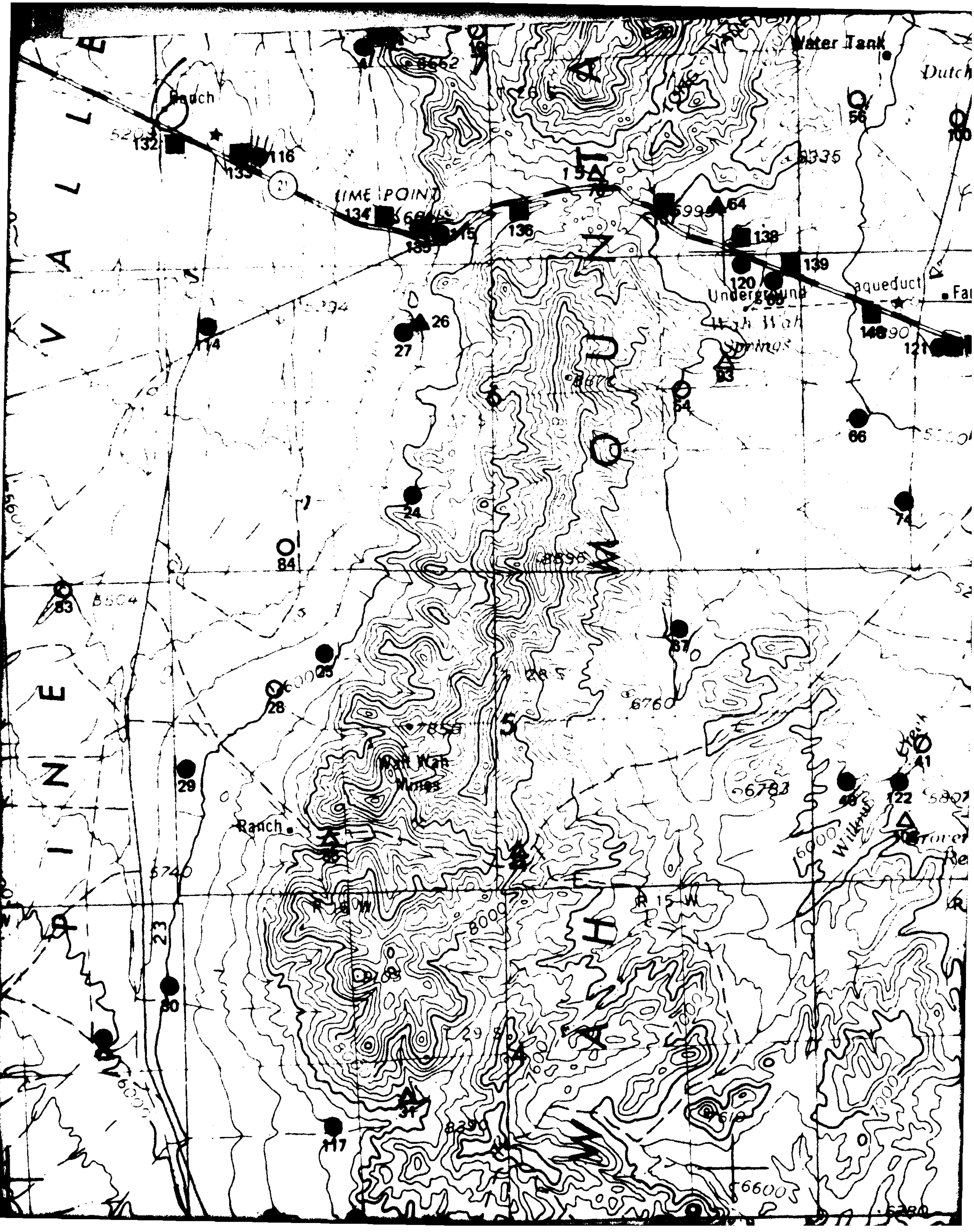
CRYSTAL PEAK
GRASSY COVE
GRAY HILLS
LAWSON COVE
T 23 S
T 24 S
R 16 W
R 15 W
R 14 W
5420
5859
6050
5380
5209
5200
5800
6000
5400
5690
6057
5208
7
8
9
16
1
2
34
58
60
61
79
22

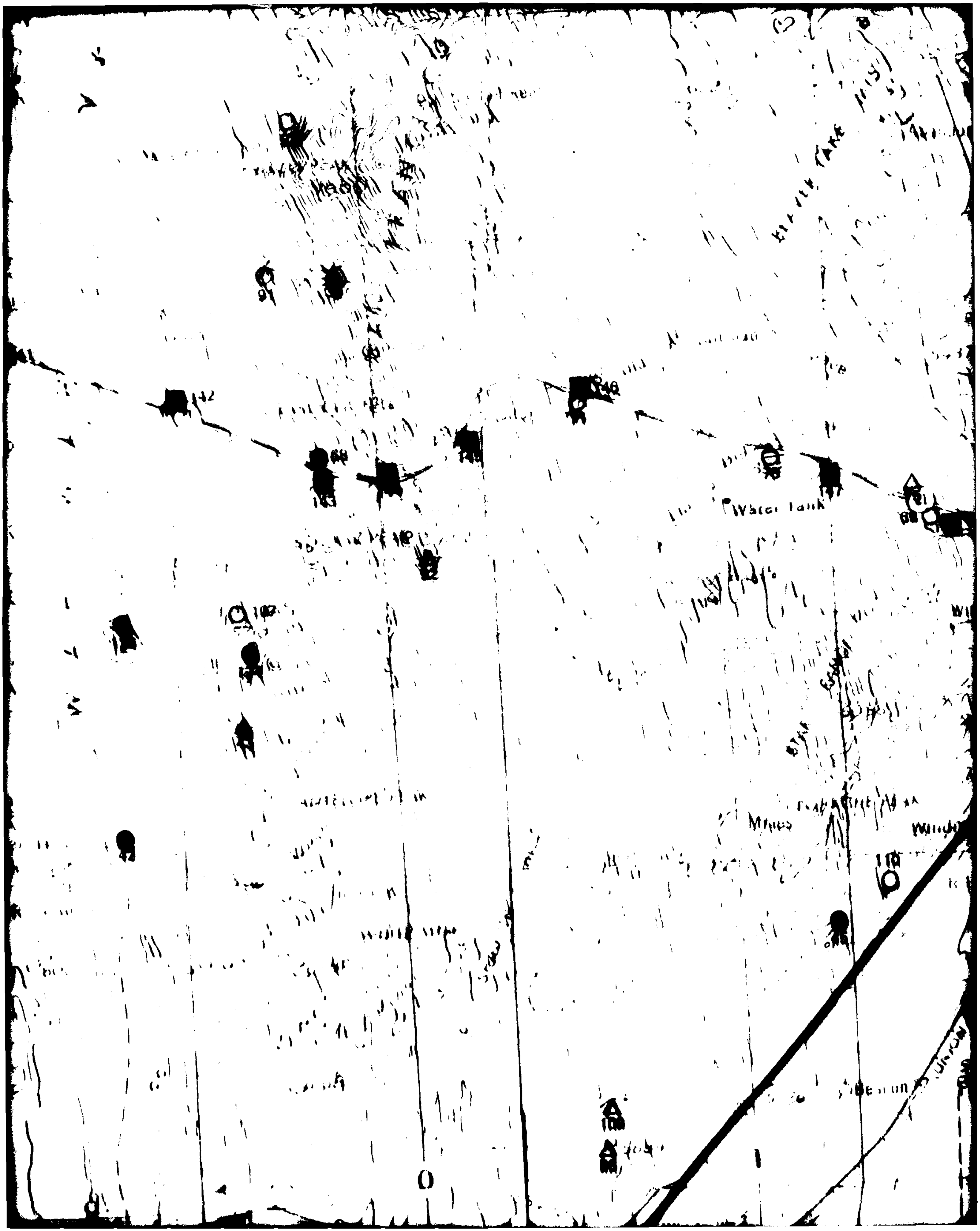


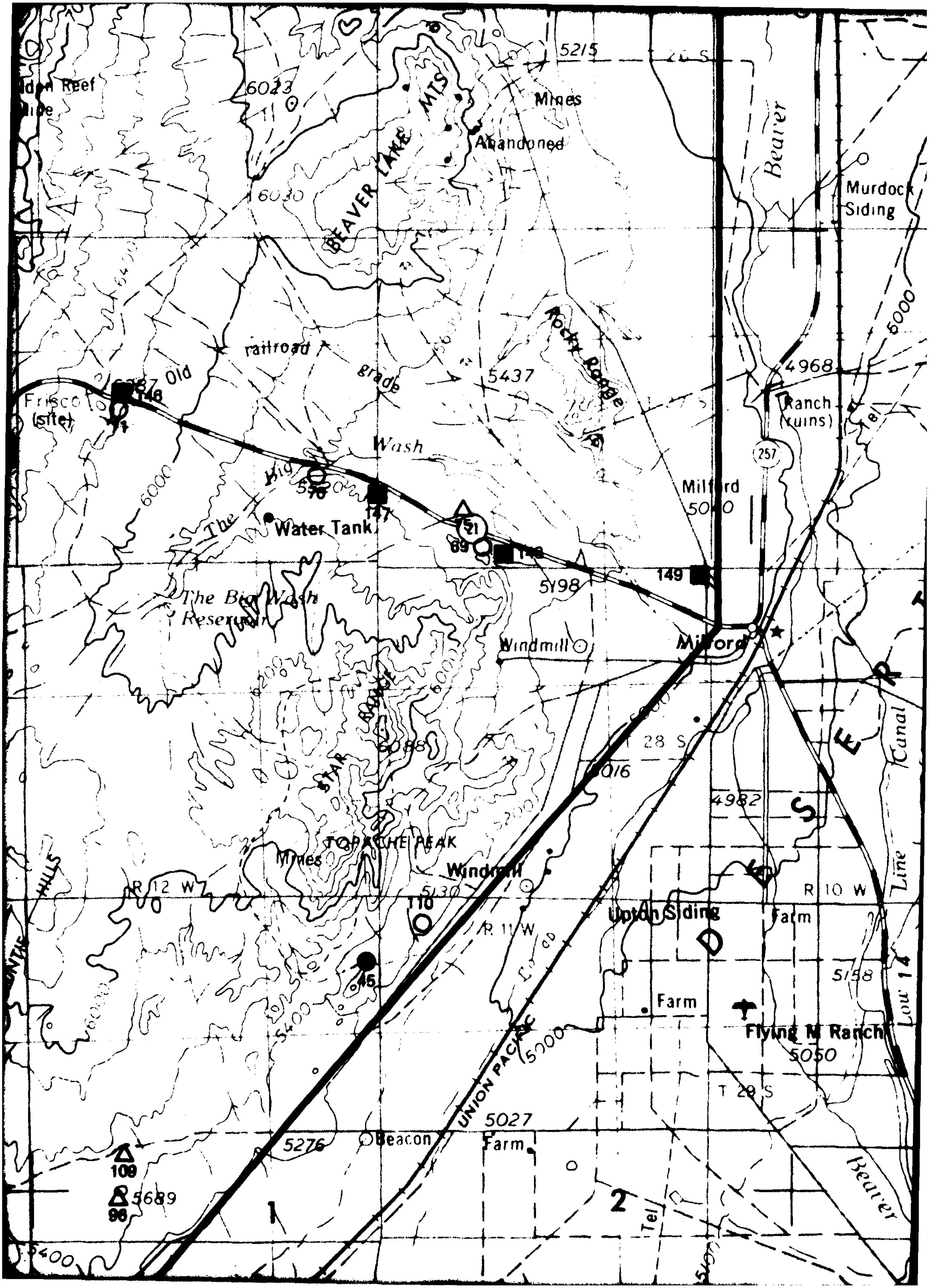
L A K E
4929
Steamboat Pass
1
4800
73
94
BROWN
KNOLL
55
35
5045
72
19
128
4740
37
36
Wah Wah Valley
Hardpan
51
4695
127
102
5445
38
50
6230
126
527
103
18


L A K E
Water
1
2
3
5380
94
845
72
19
RED ROCK
BEAVER
BOTTOMS
UNION PACIFIC
4900
R 10 W
37
5685
4890
Water
5400
102
50
6230
5000
River
Read
Windmill
103

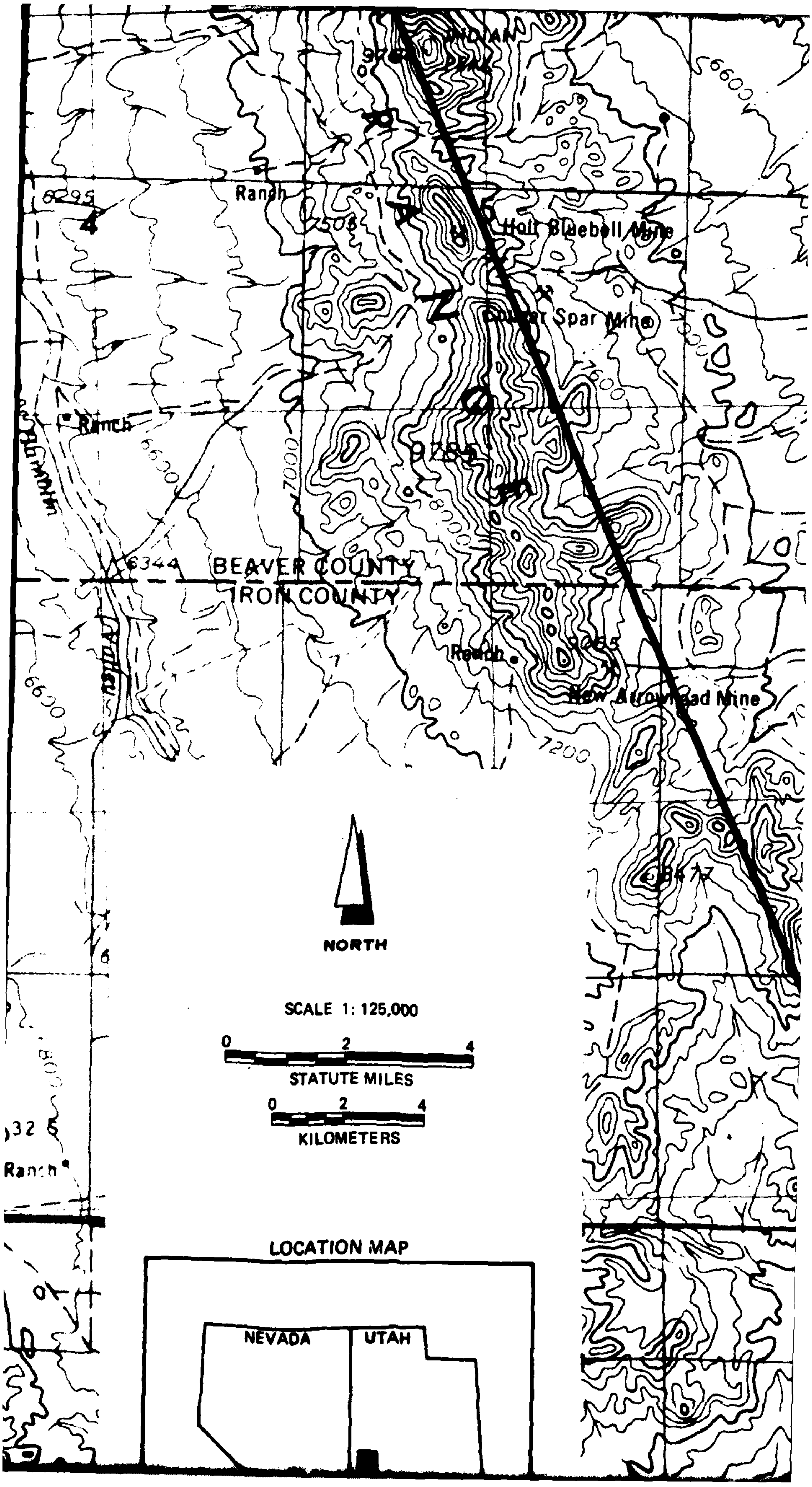
P I N E V A L L
5
6
7
13
Ranch


Water Tank
Dutch
Ranch
LIME POINT
Underground
Wah Wah Springs
aqueduct
Wah Wah Mines
Ranch
R 15 W
8896
6760
6783
5740
8000
6600
21
23
132
133
116
134
135
115
136
138
139
140
121
120
27
26
114
93
54
66
24
84
74
83
87
25
28
29
41
122
30
31
117
56
100

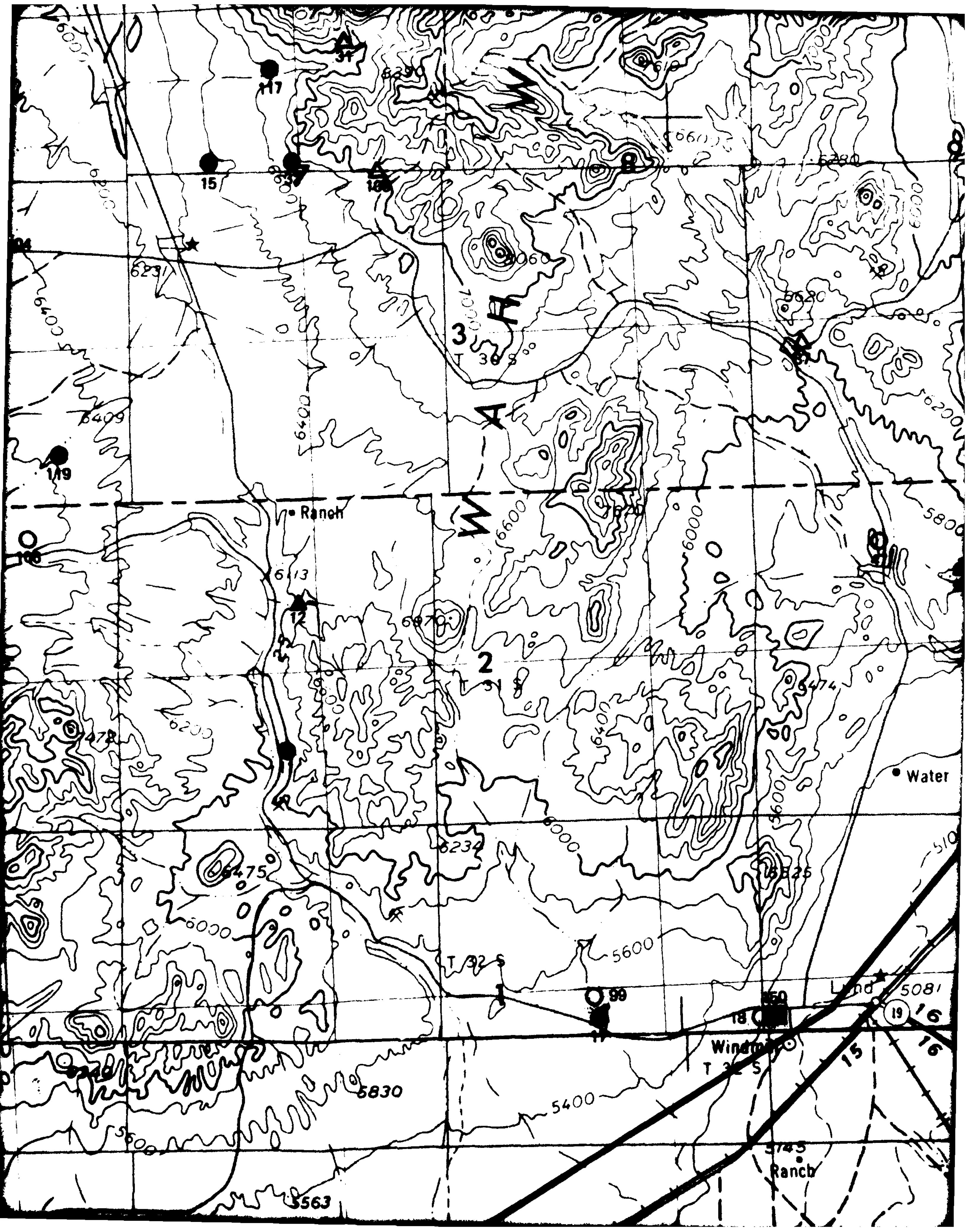

Mines



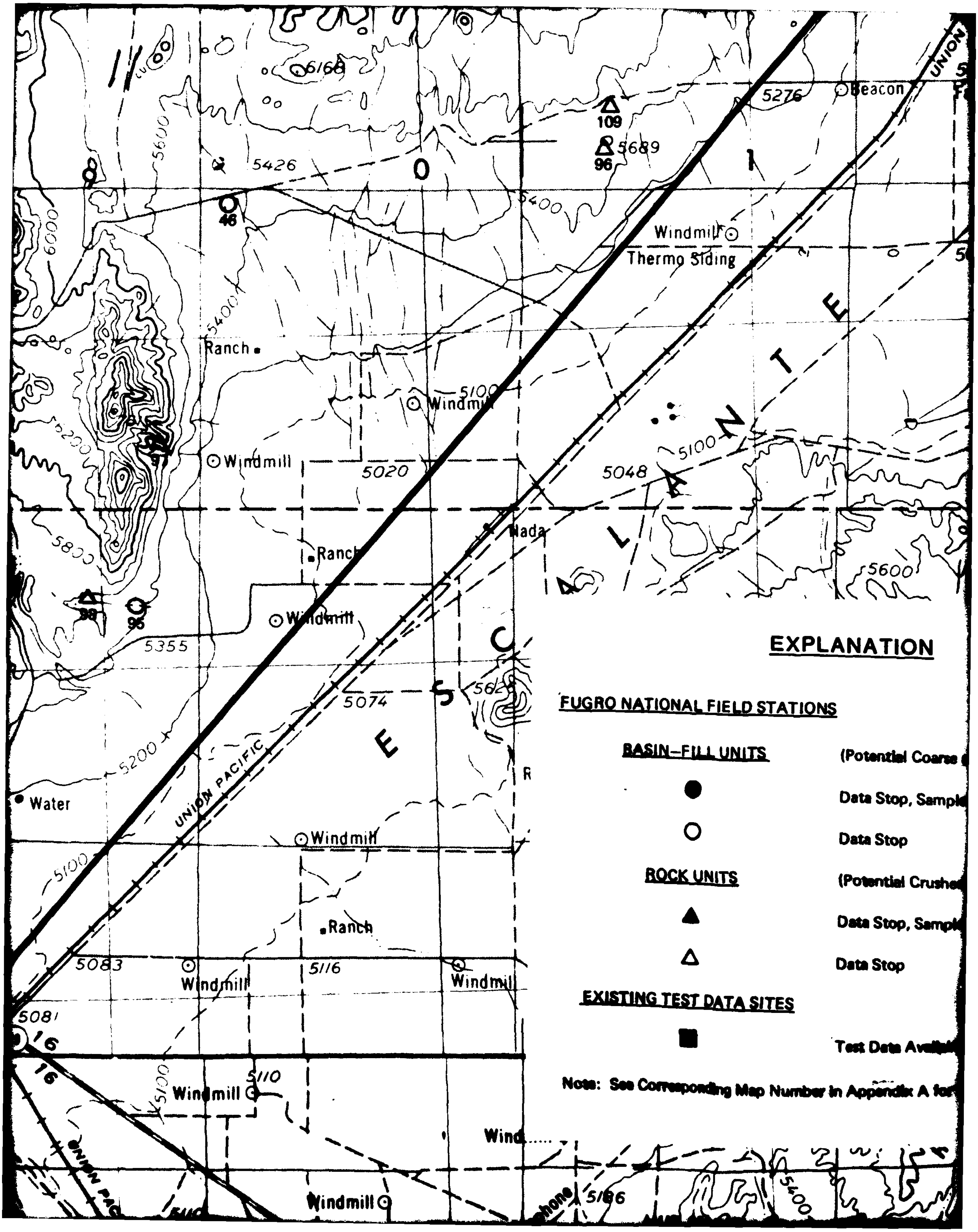
BEAVER LAKE MTS
Mines
Abandoned
5215
6023
6030
Beaver
Murdock
Siding
5000
4968
Ranch
(ruins)
257
Rocky Range
5437
railroad
grade
Old
Frisco
(site)
146
Wash
The Big
147
148
149
Water Tank
Milford
5040
5198
The Big Wash
Reservoir
Windmill
Milford
6000
6088
STAR RANGE
28 S
5016
4982
TOPACHE PEAK
Mines
Windmill
R 12 W
R 10 W
5130
110
R 11 W
Upton Siding
Farm
Canal
Line
45
5158
Farm
Flying M Ranch
5050
UNION PACIFIC
5000
T 29 S
5027
5276
Beacon
Farm
109
5689
96
1
2
Tel
Beaver
5400

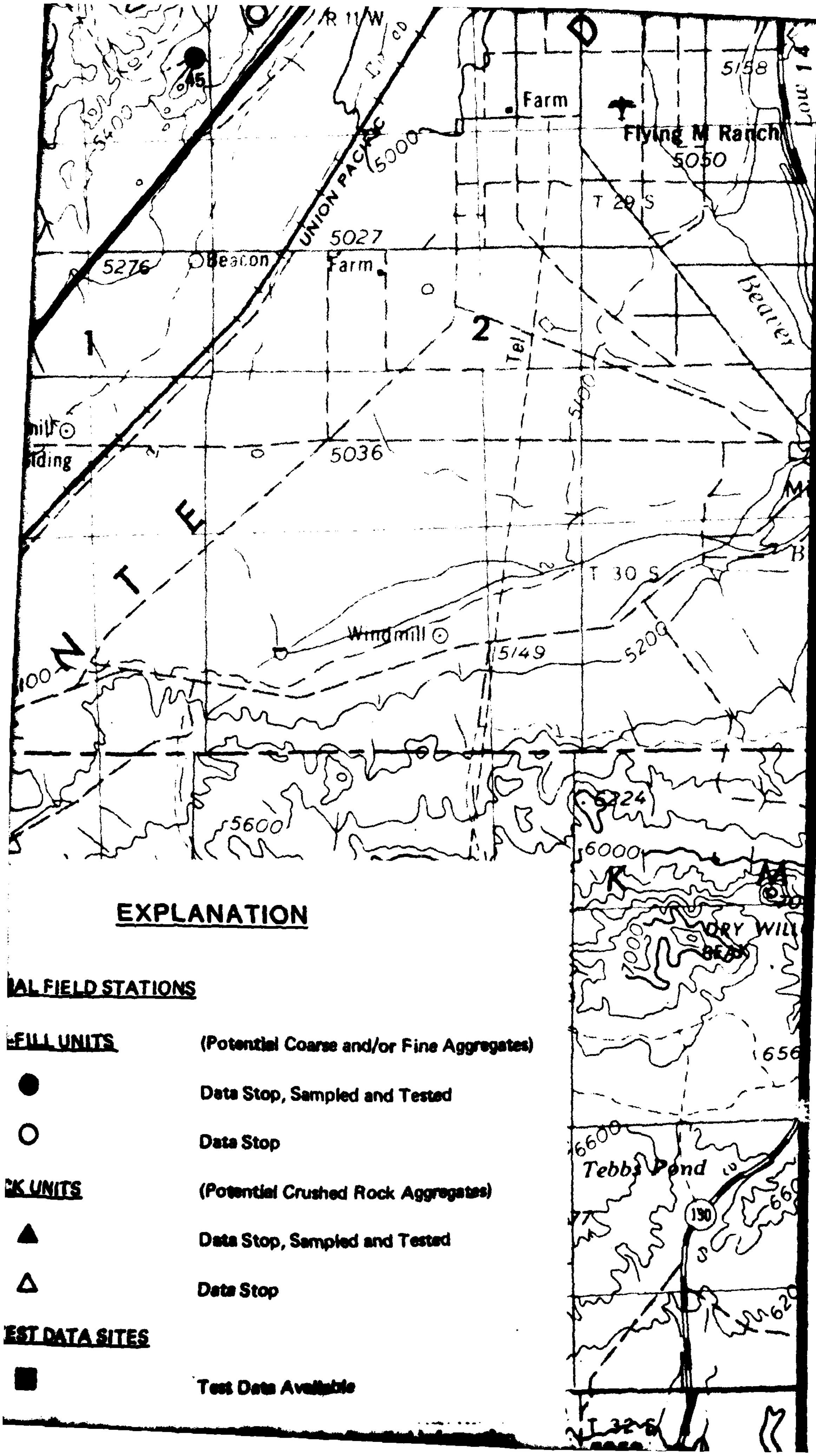


INDIAN
Ranch
6295
4
Holt Bluebell Mine
Spar Mine
Ranch
6600
7000
7600
9285
6344
BEAVER COUNTY
IRON COUNTY
Ranch
New Arrowhead Mine
7200
8477
NORTH
SCALE 1: 125,000
0 2 4
STATUTE MILES
0 2 4
KILOMETERS
Ranch
LOCATION MAP
NEVADA
UTAH



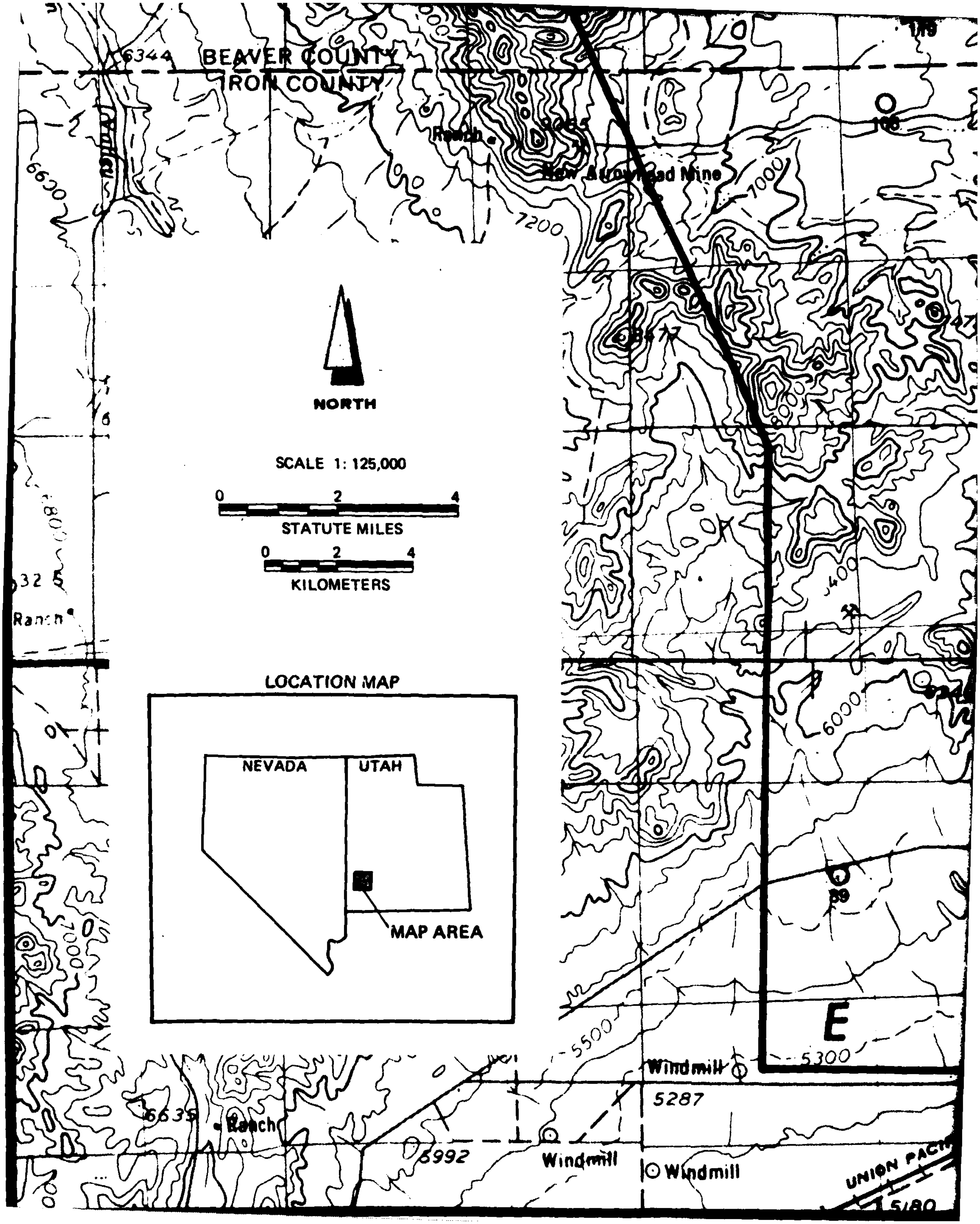
Ranch
Water
Ranch
T 32 S
5600
5400
5830
5563
6475
6234
5081
6400
6000
5800


EXPLANATION
FUGRO NATIONAL FIELD STATIONS
BASIN-FILL UNITS
(Potential Coarse
Data Stop, Sample
Data Stop
ROCK UNITS
(Potential Crushe
Data Stop, Sample
Data Stop
EXISTING TEST DATA SITES
Test Data Avail
Note: See Corresponding Map Number in Appendix A for
ESCALANTE
UNION PACIFIC
Beacon
Windmill
Thermo Siding
Ranch
Nada
Water
5276
5689
5426
5168
5100
5020
5048
5355
5074
5200
5083
5116
5081
5110
5186
5600
5400
6000
5800
109
96
46
97
98
95
16

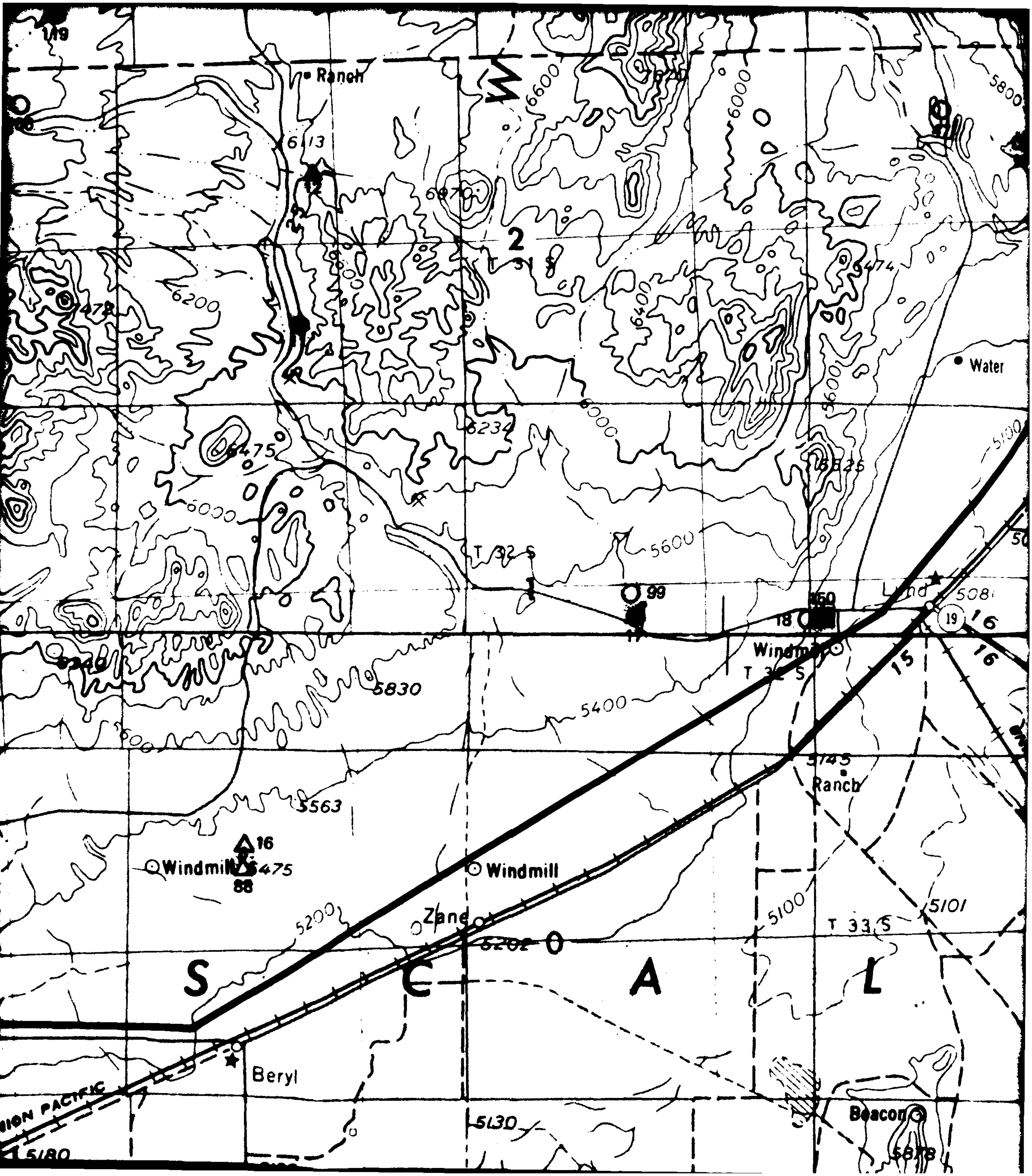


R 11 W
Farm
Flying M Ranch
5158
5050
5000
UNION PACIFIC
T 29 S
5027
5276
Beacon
Farm
Beaver
1
2
Tel
5100
5036
T 30 S
Windmill
5149
5200
5224
5600
6000
6600
Tebbs Pond
130
EXPLANATION
AL FIELD STATIONS
-FILL UNITS (Potential Coarse and/or Fine Aggregates)
Data Stop, Sampled and Tested
Data Stop
CK UNITS (Potential Crushed Rock Aggregates)
Data Stop, Sampled and Tested
Data Stop
EST DATA SITES
Test Data Available

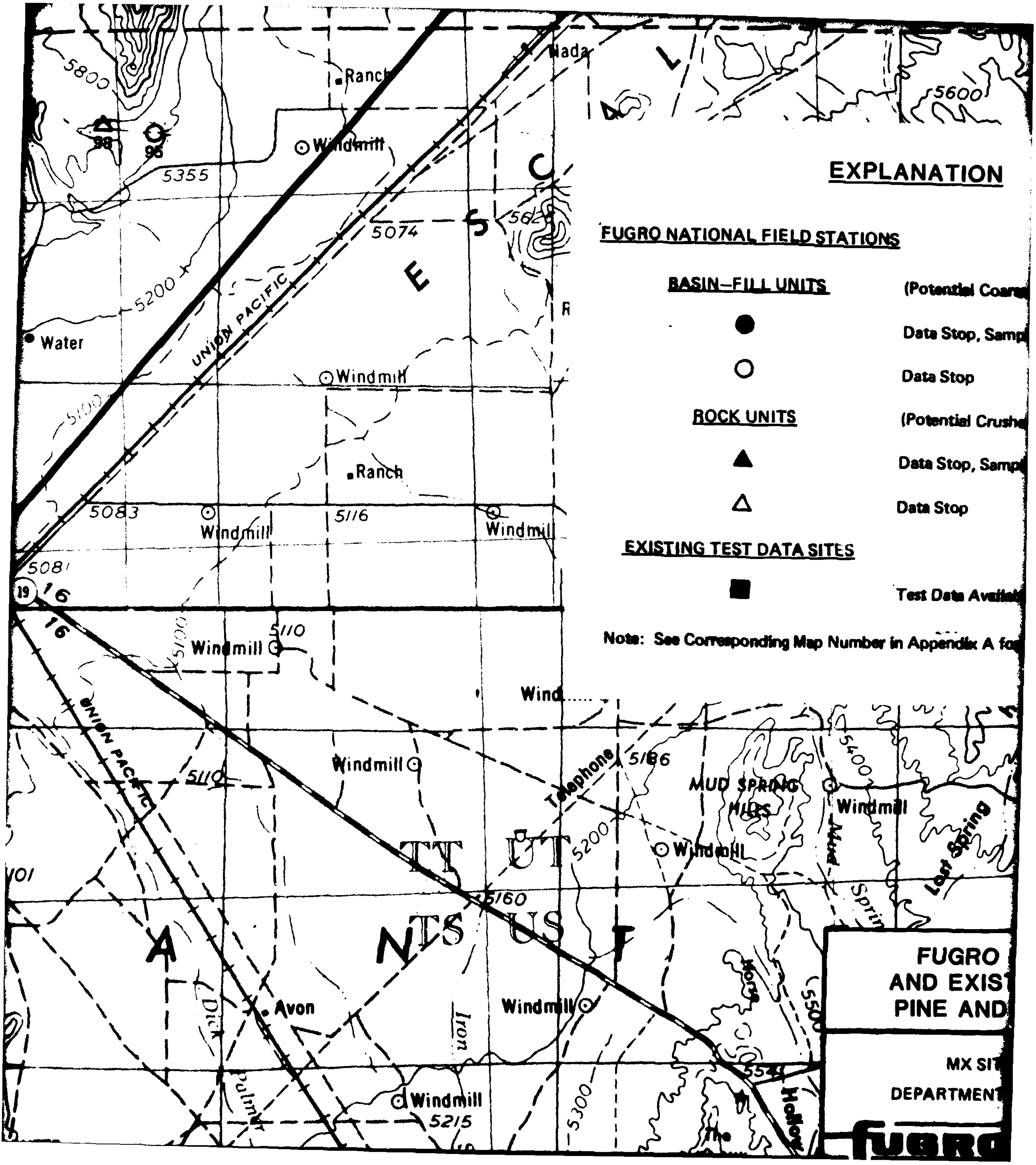
12



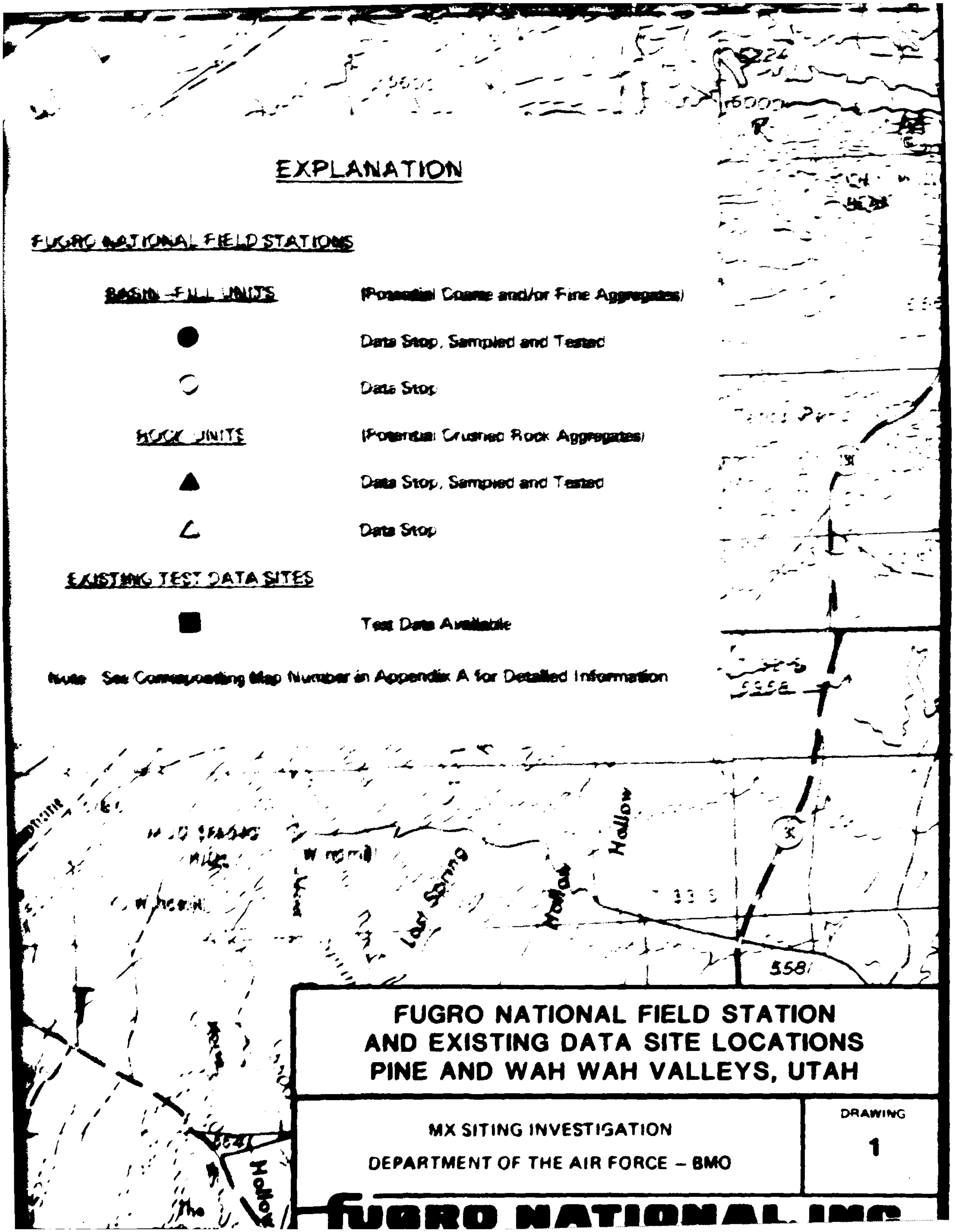
BEAVER COUNTY
IRON COUNTY
Ranch
New Arrowhead Mine
7000
7200
6344
6620
NORTH
SCALE 1: 125,000
0 2 4
STATUTE MILES
0 2 4
KILOMETERS
LOCATION MAP
NEVADA
UTAH
MAP AREA
6000
5500
5300
E
Windmill
5287
6635
Ranch
5992
Windmill
Windmill
UNION PACIFIC
5180



Ranch
6600
6000
5800
2
6200
Water
6234
6475
6000
5600
T 32 S
99
Lund
19
16
15
18
Windmill
5830
5400
Ranch
5563
16
Windmill
6475
88
Windmill
5200
Zane
5100
5101
T 33 S
S
C
A
L
Beryl
Beacon
5130
5180



EXPLANATION
FUGRO NATIONAL FIELD STATIONS
BASIN–FILL UNITS
(Potential Coars
Data Stop, Samp
Data Stop
ROCK UNITS
(Potential Crush
Data Stop, Samp
Data Stop
EXISTING TEST DATA SITES
Test Data Availa
Note: See Corresponding Map Number in Appendix A fo
FUGRO
AND EXIS
PINE AND
MX SI
DEPARTMEN
fugro
5800
Ranch
Wada
5600
98
96
Windmill
5355
5074
5200
UNION PACIFIC
Water
5100
Ranch
5083
5116
Windmill
5081
19
16
5110
Wind
5186
Telephone
MUD SPRING HILLS
5400
Lost Spring
5200
5160
Avon
Iron
Dick
Palmer
5215
5300
5500
Hollow


EXPLANATION
FUGRO NATIONAL FIELD STATIONS
BASIN-FILL UNITS
(Potential Coarse and/or Fine Aggregates)
Data Stop, Sampled and Tested
Data Stop
ROCK UNITS
(Potential Crushed Rock Aggregates)
Data Stop, Sampled and Tested
Data Stop
EXISTING TEST DATA SITES
Test Data Available
Note: See Corresponding Map Number in Appendix A for Detailed Information
Hollow
Lost Spring
Hollow
5581
FUGRO NATIONAL FIELD STATION
AND EXISTING DATA SITE LOCATIONS
PINE AND WAH WAH VALLEYS, UTAH
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO
DRAWING
1
FUGRO NATIONAL, INC.

DA
FILM
4-